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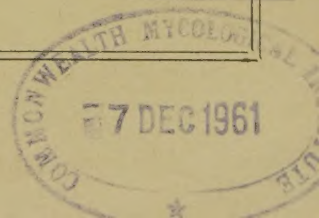
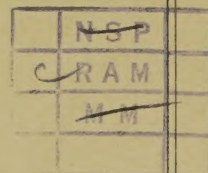
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The Relation of Water Absorption to Germination of Rice Seed

Norindo TAKAHASHI

(Received February 21, 1961)

I. Introduction

The germination of seed is influenced by various internal and external factors. This report is a part of the studies on the analysis of these internal factors regulating the germination in rice seed. The first change when seeds are placed to germinate is the imbibition of water. Beginning with the water absorption various physical and chemical changes immediately take place in the seed and after then the seed germinates. Accordingly the characteristics and the reactions of the seed with regard to the water absorption are the most important physiological phenomena.

However, almost no studies have been reported on the pattern of water absorption and its significance in the rice seed.

The study are, therefore, made to determine the characteristic of water absorption in the seed during the germination process. Moreover, the interrelationships of the water absorption and the seed coat, embryo, or endosperm are discussed in this paper.

II. Materials and Methods

The experiments are undertaken to study the pattern of water absorption, the mechanism of water intake in the seed and the effect of environmental factors which influence water absorption.

The seed of rice variety Ōu-no.-200 was used. The seeds were hulled and sterilized for ten minutes with 5 per cent solution of calcium hypochloride. After then the seeds were laid on the moist filter paper or in the test solution to examine several problems.

In the experiments of water absorption, 25 seeds were used for each estimation. All estimations were repeated four times. The determinations of moisture content in the seed were carried out by a Metra Chemical Balance (direct reading balance).

Surface water on seed was removed from each sample before weighing by

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gentle pressing between several layers of gauze cloth and the fresh weight was weighed. After then the seeds were dried to a constant weight at 100°C.

III. Results and Discussion

1. Pattern of water absorption during germination

The initial steep of absorption of water in the seed occurs during the first 18 hours. It may be due to imbibitional force. From about 18 to 72 hours almost no further increase of absorbed water occurs. The last rapid absorption of water in the seed occurs after 72 hours. The last elevation of water may correspond with the growth of the embryo. Namely, the pattern of water absorption is divided into three phases, Phase A, (the first phase shows the initial steep increase of water) Phase B, (the second phase shows the suspension of water absorption) and phase C, (the third phase shows the final elevation of water absorption). From the view point of water absorption, it is implied that "germination" means the appearance of a part of the embryo through the membranes surrounding it.

In some seeds embryo development starts as soon as water is absorbed, while in others germination does not take place until other factors are fulfilled after imbibition. The former is recognized in completely after-ripened seed and the

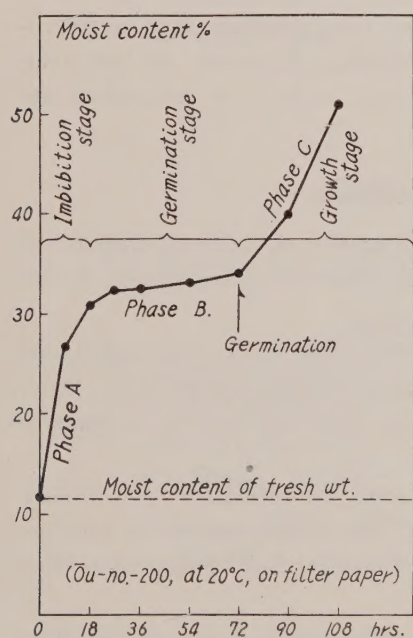


Fig 1.

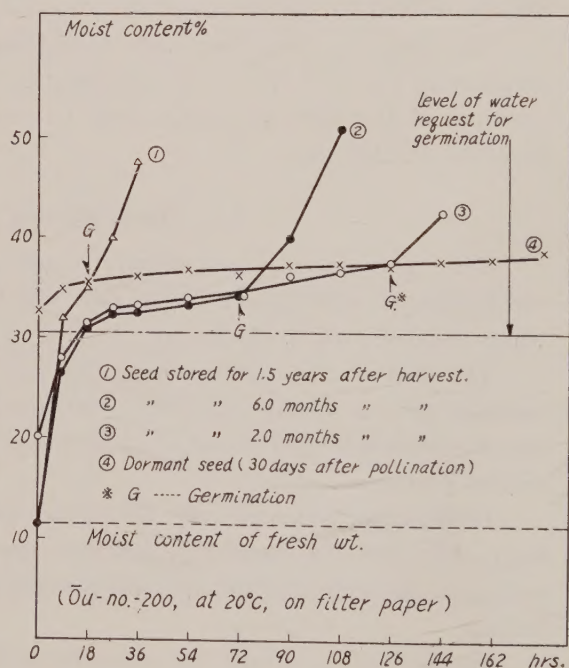


Fig 2.

Fig 1. The pattern of water absorption during the germination of the rice seed.

Fig 2. The water absorption of the seed after storage for various periods.

latter is shown in the dormant seed or the incompletely after-ripened seed.

Accordingly, the velocity of germination is regulated by two phases, A and B (Figure 1 and 2).

2. Feature of Phase A and Phase B

(i) Effect of temperature

The rate of water absorption is influenced by temperature. The effect of temperature extending from 15° to 30°C on water absorption was examined (Fig. 3). Temperature coefficient (Q_{10}) for the rate of water absorption in Phase A was recognized to be lower than that conforming to the Van't Hoff's law, and the coefficient in phase B was about 2~3. From the values of Q_{10} in Phase A and Phase B, therefore, the water absorption in Phase A may be mainly a physical process, while that in Phase B may be considered a physiological process. Brown and Worley¹⁾ studied the effects of temperature upon the rate of water absorption in barley seeds. They pointed out that the velocity of water absorption was almost an exponential function of temperature and the temperature coefficient of water absorption in seed is 2. Shull²⁾ pointed out that the Brown-Worley theory could not be recognized in his data using seeds of cocklebur and pea seed cotyledons, and the velocity of water absorption at any case was found to be approximately an inverse exponential function of the amount of water previously absorbed.

Shull and Shull³⁾ also reported that the rate of absorption at 55° was

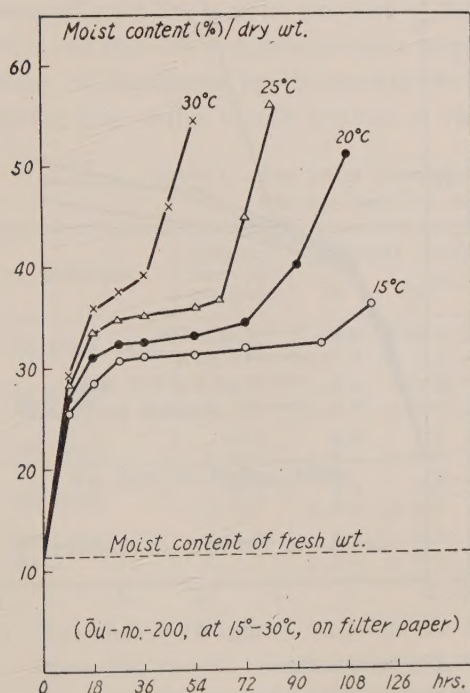


Fig 3. The water absorption in seed under different temperatures

somewhat more than eight times as great as at 5°C, while the Brown-Worley theory of water by rising temperature would be 32 times as great at 55° as at 5°.

The fact agreed with the earlier work on cocklebur and pea cotyledons. Osterhout⁴⁾ concluded that the temperature coefficient of permeability in the plant cell was not chemical in nature. Denny⁵⁾ suggested that the temperature coefficient is lower than that according to the van't Hoff's law, and is higher than the diffusion coefficient.

(ii) Effect of H₂, N₂ or CO₂ gas and metabolic inhibitors

The seed used in this test was stored for about one year in the desiccator with CaCl₂. The moisture content of the seed was 11.6 per cent in average. To examine the effect of H₂, N₂ or CO₂, the seeds were laid on filter paper moistened with pH 4.9 Potassium Biphthalate buffer solution in a test tube filled up with each gases. While, examining the effect of the metabolic inhibitor, the seeds were soaked in the solution of each metabolic inhibitors (pH 4.9; 10⁻²—10⁻³ M. KCN, NaN₃, Na-Benzotate, Monoiodo Acetic Acid, and 2.4 D.N.P.) The attention was paid to renew the test solution every day.

In both experiments, at a suitable time the seeds were collected and the moisture

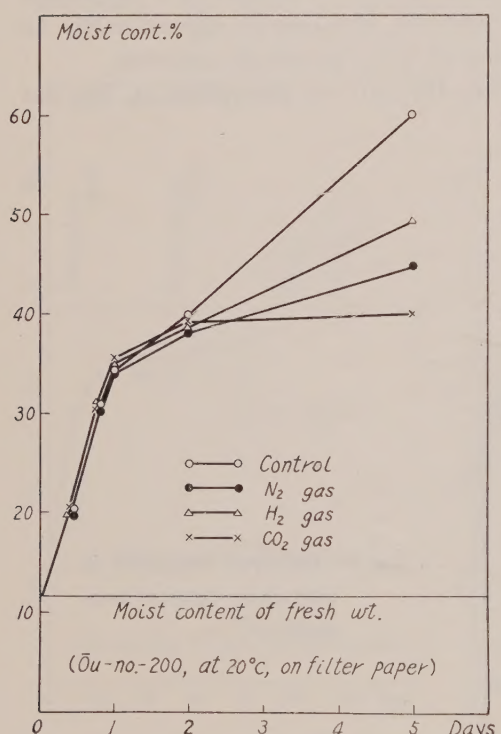


Fig. 4.

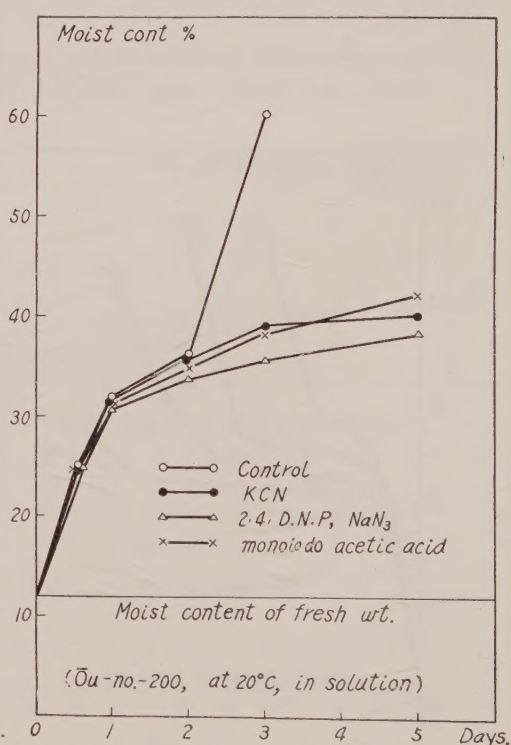


Fig. 5.

Fig. 4. The water absorption of seed under the various gases.

Fig. 5. The water absorption of seed under the solution of various inhibitors.

content in the seed was weighed rapidly. From the results of the two experiments the significant difference of water absorption in Phase A between each treatments could not be recognized (Fig. 4 and 5). It may be suggested that the Phase A is different from the other phase and is not related to the metabolic process.

3. Selective semipermeability of seed coat

(i) Imbibition of rice seed in solution of NaCl

Crocker⁸⁾ pointed out that the permeability of the outer membrane in the seed to both gases and water are important in the behavior of the seed. It is generally considered that the most evident factor affecting water absorption or gaseous exchange by the seed is the nature of the outer membranes in seed. Brown⁷⁾⁸⁾ reported the discovery of a semipermeable membrane forming the outer layer of *Hordeum vulgare* and published on the nature of selective permeability of the outer dead membrane of the seed. Semipermeability of the outer membrane in the seed has been usually demonstrated for many kind of seeds. As Crocker and Barton⁹⁾ pointed out, the characteristic of the seed coat must be considered in a study of germination behavior in the seed. Shull¹⁰⁾ indicated the existence of a very efficient semipermeable membrane in the seed, by determining the amount and rate of imbibition of cocklebur seeds in solution of sodium chloride of various strengths.

In this experiment, in which a strong solution of sodium chloride instead of distilled water was used with the rice seed, the initial water absorption was rapidly increased until the osmotic pressure of the salt of the outside balances the internal force, and then the entrance of water stopped. And also, the mechanical nature in Phase A was shown by the entrance or withdrawal of water in the rice seed on shifting from water to salt solution or vice versa. (Table 1)

Table 1. The water absorption of seed in NaCl solutions of various strengths, and distilled water at 16°C.

Solutions	Original fresh wt. mg/grain	Percent. water absorbed				Percent. water absorbed at 18hrs after shifting from original soln. to different soln.
		24	72	96	120hr	
Distilled water	24.2 ± 0.9	13.9 ± 1.8	20.2 ± 1.1	21.1 ± 1.7	24.4 ± 1.2	4.4 ± 1.3 : to 4M NaCl
1M NaCl	25.3 ± 1.2	10.0 ± 0.6	12.43 ± 0.9	13.5 ± 1.0	14.1 ± 1.1	15.0 ± 1.3 ———
2M NaCl	24.4 ± 2.0	6.6 ± 0.4	7.9 ± 0.4	8.7 ± 0.4	9.0 ± 0.3	28.4 ± 0.4 : to dist. water
4M NaCl	24.9 ± 1.4	4.4 ± 6.2	4.4 ± 0.3	4.4 ± 1.0	4.5 ± 0.2	5.5 ± 0.2 ———
Saturated NaCl	25.32 ± 1.2	2.5 ± 0.3	2.6 ± 0.4	2.6 ± 0.6	2.9 ± 0.4	8.5 ± 0.8 : to 2M NaCl

(ii) Entrance pathway of water in the rice seed.

From the results mentioned above, it is suggested that the membranes surrounding seed are semipermeable. By using NaCl and AgNO₃, the fact was also

tested, that is, the pericarp within the outer membranes allowed NaCl to penetrate but the seed coat does not allow NaCl to reach the inner part.

When the rice seed was soaked in iodine- potassium iodide solution (1 per cent solution of iodine in 5 per cent solution iodide of potassium) for 60 minutes at 20°C the passage of iodine through the membrane covered the part of embryo and the endosperm was evidently observed by the granules stained with iodine in the endosperm. When the rice seed stained with iodine was soaked in 15-20 per cent solution of sodium hyposulphite, the sodium hyposulphite could not diffuse into the grain by semipermeable membrane and the starch stained with iodine was not discoloured. By making a cross section of the seed with a razor, it was observed that the starch grains stained blue and shows the pathway of water penetration and then the water might be penetrated more easily along the aleuron layer rather than in any other parts of the endosperm. (Photograph 1)

4. Environmental factors influencing the pattern of water absorption

The various environmental conditions are of importance in seed formation and have effects on the germination of the rice seed. Kakizaki¹¹⁾ pointed out that the germination velocity of rice seed produced under unusual cold climatic condition was remarkably dull as compared with the seed produced under the favorable climatic condition. Kanda et al¹²⁾ reported that by using a certain variety, the germination velocity of seeds produced under different climatic conditions was different from each other. In the experiment, the rice plants were cultured under different environmental conditions, i.e. different nutrition and day length. The seeds from these plants were tested to determine the germination velocity.

(i) Effect of nutrition

The germination in the seed from potassium deficient plant delayed remarkably as compared with others (Table 2). But it was difficult to distinguish the initial water absorption in phase A between them. Accordingly, the difference of germination velocity was certainly due to the behavior of phase B.

Table 2. The relationship between germination velocity and the water intake in rice seed harvested from the rice plant grown under a different condition. K...potassium, P...phosphorus)

Treatments	Control	K deficient	P deficient
Time of germination (hrs.)	72.0 \pm 2.5	48.9 \pm 3.1	70.3 \pm 2.3
Water content at 18hrs after planting (%)	28.9 \pm 1.9	30.6 \pm 2.4	29.5 \pm 3.4

(ii) Effect of day length

Among the environmental factors, the light plays an important role in the seed

formation. Photo-periodic effects have been examined widely in relation to the induction of flowering but seed setting and maturation have not been clear. It is especially suggested that few studies on the interrelationships of the seed germination and the photoperiodic effect have been reported¹³⁾.

In the experiment, the photo-sensitive and non photo-sensitive rice varieties

Tabel 3. The state of seed harvested under the different day length.

Varieties and treatments	Ōu-no.-200 (Japonica)		Shirokara (Indica)	
	8hr. day length	Natural day length	8hr. day length	Natural day length
Heading day	Aug. 20	Aug. 19	Aug. 17	Aug. 20
Harvesting day	Oct. 10	Oct. 10	Oct. 10	Oct. 10
Seed size (length×width×thick, mm ³)	28.4± 2.4	30.3± 2.3	30.2± 2.0	30.9± 2.3
Dry wt. of embryo (25 grains, mg)	12.7± 0.4	13.0± 1.0	9.4± 0.9	8.9± 1.0
Dry wt. of endosperm (25 grains, mg)	370.0±56.0	340.0±24.0	330.0±50.0	324.0±43.0
Moist content of embryo (%)	28.0± 2.1	26.5± 0.2	25.9± 5.0	26.1± 1.9
Moist content of endosperm (%)	12.5± 3.4	11.2± 0.8	33.0± 5.0	32.4± 4.3

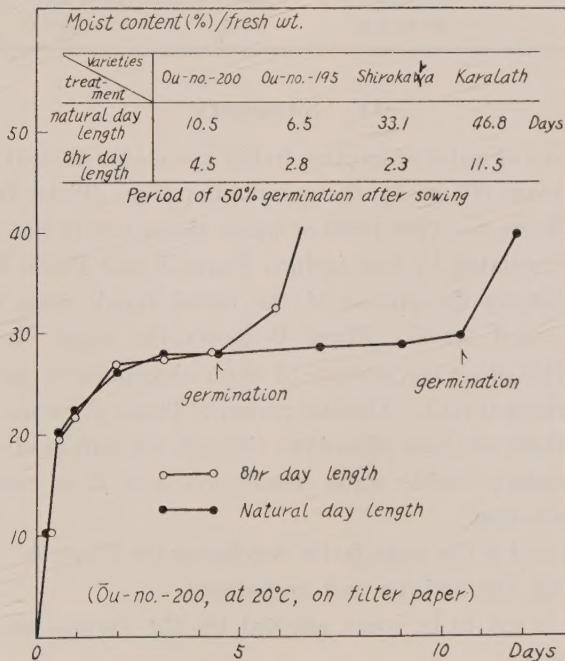


Fig 6. The water absorption of seed harvested under different day length (1.5 months after harvest)

were used and their seed produced under different day length, i.e. 8 hour day length and 16 hour day length. By using these seeds the germination velocity was observed. As the seeds from 16 hour day length treatment, however, were mostly green seeds, they were not used in the test. Table 3 shows the morphological character of their seeds. The result shows that it is difficult to distinguish the difference of morphological character. From figure 6 the initial water absorption in Phase A was not different from others. To clarify the cause of difference produced in the seed by photoperiodic treatment, the embryo and endosperm were separated and the oxygen uptake in each part was observed.

In Table 4 it is suggested that the difference of germination velocity in the seed is due to the endosperm rather than the embryo. As mentioned above, Phase B is apt to be more affected than Phase A by the various environmental conditions, especially the endosperm may be strongly influenced by environmental factors.

Table 4. O_2 uptake of seed formed under the different light conditions at 48hrs. after incubation (Q_{O_2} /dry wt. hr.)

Parts in seed \ O_2 uptake	8hr. day length		Natural day length	
	$Q_{O_2}/50$ grains	$Q_{O_2}/100$ mg	$Q_{O_2}/50$ grains	$Q_{O_2}/100$ mg
Whole seed	112.6 ± 1.5 μl	14.3 μl	81.6 ± 2.1 μl	9.3 μl
Embryo	60.2 ± 2.9	254.3	53.0 ± 3.1	264.6
Endosperm	52.4 ± 2.0	6.5	26.7 ± 1.5	3.5

IV. Summary

(1) The pattern of water absorption in the rice seed is divided into three phases i.e. the imbibition stage (Phase A), the germination stage (Phase B) and the growth stage (Phase C). From the view point of water absorption in the seed, the velocity of germination is regulated by two factors, Phase A and Phase B.

(2) Phase A shows the process of the initial rapid water absorption when imbibition in the seed occurs. Phase B shows the stage of organization for germination. At this phase the increase of water absorption is not remarkable, and if it happens, the rising is dull. The last period of Phase B means the germination, that is, the appearance of tissue of embryo through the surrounding coats. Phase C shows the secondary visible water absorption and it is concerned with the growth after germination.

(3) The seed coat is the main factor regulating the Phase A. Phase B may be mainly governed by the embryo and endosperm.

(4) Phase B is apt to be more affected by the various environmental conditions than Phase A.

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Fig. 1.

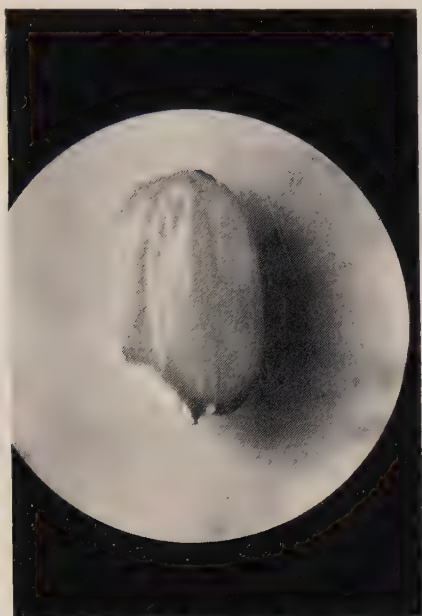


Fig. 2.

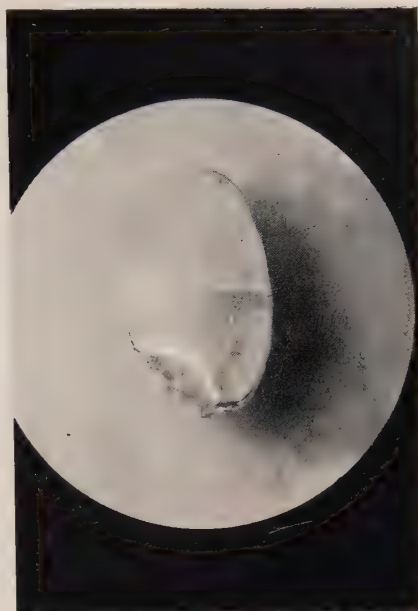
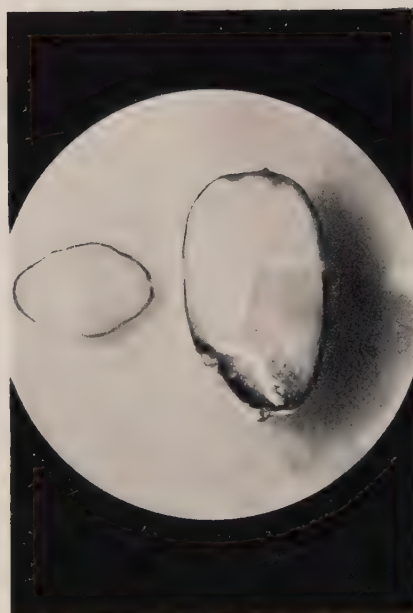


Fig. 3.



Fig. 4.



Penetration of iodine through the seed coat at 20°C
Figs. 1-2. after 40 minutes Figs. 3-4. after 120 minutes

Metabolism in Muck Paddy Soil

Part 3. Role of soil organic matter in the evolution of free hydrogen sulfide in water-logged soil

Ichiro YAMANE and Ikuo SATO

(Received March 1, 1961)

I. Introduction

For many years it has been thought that sulfate reduction in the water-logged soil has a great influence on the growth of the rice plant. Osugi and Kawaguchi¹⁾ stated that the root injury of the rice plant in some paddy fields was caused by the formation of sulfide due to the reduction of sulfate contained in fertilizer. Shioiri²⁾ pointed out that the root injury in Akiuchi-paddy soil (which is expressed sometimes by "aged paddy soil" or "degraded paddy soil" in English) was caused by the free hydrogen sulfide which is formed due to the lack of iron sufficient to catch hydrogen sulfide derived from the reduction of sulfate. Though the importance of hydrogen sulfide formation in rice paddy soil, especially in Akiuchi-paddy soil, has been well recognized since Shirori's work, the behavior of sulfate, sulfide and hydrogen sulfide in water-logged soil has not been well studied owing to the difficulties of their analytical methods.

The writers have performed the field experiment in a muck paddy field to increase its rice yield, and found little effect of iron compound to prevent the evolution of free hydrogen sulfide in this field. In general, sulfate is reduced to hydrogen sulfide in water-logged soil and hydrogen sulfide is precipitated as iron-sulfide by reaction with active iron. But when there is not enough active iron, free hydrogen sulfide is evolved and injures rice root.

In spite of the existence of much iron, the evolution of free hydrogen sulfide in the muck paddy field may be due to the inactivation of iron by means of the complex formation of active iron with soil organic matter.

The writers wished to clarify the function of soil organic matter in metabolism in rice paddy soil, and divided the soil organic matter into two categories, i.e., (i) decomposable organic matter as a substrate for soil microorganisms and (ii) organic colloid³⁾. In this paper they desire to show the function of decomposable organic matter and organic colloid in the evolution of free hydrogen sulfide. In addition,

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the research on the transformation of sulfur compound is one of the most important keys to clarify the metabolism in rice paddy soil.

Experiments in this paper consist of three parts, i.e., (1) analytical methods of sulfur compounds in flooded soil, (2) role of easily decomposable soil organic matter in the reduction of sulfate to sulfide, and, (3) role of soil organic colloid in the effect of added iron oxide on preventing the formation of free hydrogen sulfide.

II. Experiment (1) -Analytical method of sulfur compounds in flooded soil

Lack of adequate methods of sulfur compounds, especially sulfide and hydrogen sulfide, has prevented the progress of the research of the transformation of sulfur compounds in flooded soil. And so several methods were tested and modified, and the following methods were adopted.

1. Determination of sulfate

There are many methods for determining sulfate, but it is very difficult to find a handy and accurate method which fulfills the exactness required in the following experiment.

The writers adopt the Fiske's benzidine method⁴⁾ but its procedure is rather complicated. A more handy method should be recommended in the future.

(i) Procedure

After extraction by $\text{N-NH}_4\text{Cl}$, sulfate is determined by Fiske's benzidine method. Procedure is as follows. Ten fold of volume of $\text{N-NH}_4\text{Cl}$ is added to soil and shaken for one hour. After filtration of extracts, a certain volume of the filtrate which contains about 0.5 mg of sulfate-S is taken in a porcelain dish and evaporated to dryness. NH_4Cl is decomposed by addition of aqua regia and the water soluble portion is filtered into the micro-beaker (10 mm diameter and 25 mm high). After cooling, dil. NH_4OH is added until a blue color as indicated by bromphenol blue and then 2 per cent HCl is added until a yellow color appears. If iron is precipitated, iron should be removed by the usual method. Benzidine sulfate is precipitated by the addition of 1 ml of benzidine (4 g benzidine is solved in 50 ml of N-HCl and then water is added to 250 ml) and then 2 ml acetone is added.

After 30 minutes the supernatant is filtered through filter stick by sucking and then the precipitate is washed several times by acetone. Precipitate in the beaker is dried in vacume for one hour to drive off acetone. After drying, a definite volume of $\text{N}/100\text{-NaOH}$ is added to the precipitate which is solved by gentle boiling. Solution is transferred to 25 ml Erlenmyer flask through filter stick by sucking. Excess of $\text{N}/100\text{-H}_2\text{SO}_4$ is added and then $\text{N}/100\text{ NaOH}$ is titrated as indicated by phenol red under the condition of gentle boiling.

$$1 \text{ ml } \text{N}/100 \text{ NaOH} = 0.16 \text{ mg } \text{SO}_4\text{-S}$$

(ii) Some discussion.

According to the writers' test, the benzine method determines 50 per cent of thiosulfate, and 100 per cent of sulfite and sulfate. Pearsall⁵⁾ described that, in waterlogged soil, sulfate is only accumulated under oxidative condition and only sulfide accumulated under the reductive condition, but other forms of inorganic sulfur can not be accumulated. The writers did not test the existence of the other forms of inorganic sulfur compounds. A more detailed study should be required for the test of other compounds.

In the procedure, aqua regia is used to eliminate of NH_4Cl . This aqua regia treatment has a danger to oxidize sulfide which might be extracted by NH_4Cl solution. But, as described later in this paper (II), the decrease of sulfate is equal to the increase of sulfide in almost all the cases. And so this analytical method may not bring great errors to the writers' experiment. But the writers recognize the existence of sulfate in the strongly reductive condition after four weeks' incubation. There is a danger of oxidation by aqua regia in this case.

2. Determination of free hydrogen sulfide

(i) Incubation method

In incubation for H_2S determination the writers used a test tube as shown in Fig. 1, A. Glass tube is filled with water to facilitate the degassing procedure in analysis.

(ii) Procedure

In analysis, (a) is connected with 20 ml of the absorbing solution (50 g of lead acetate and 12.5 g of sodium acetate are solved in 1 l of water) through two drop catchers. Nitrogen gas comes from the bomb through the flowmeter and washing solution (Na-hydrosulfite) as shown in Fig. 3 of sulfide determination. Nitrogen is flowed at the rate of 500 ml/min for 50 minutes. Hydrogen sulfide contained in soil and water is ejected by nitrogen and absorbed in lead acetate solution. After degassing, iodine solution and HCl are added to the absorbing solution, and then the solution is titrated by sodium thiosulfate by the usual procedure of iodometry.

$$1 \text{ ml of N/100 Na}_2\text{S}_2\text{O}_3 = 0.16 \text{ mg H}_2\text{S-S}$$

(iii) Some discussion.

Free hydrogen sulfide can be measured by this procedure. But a problem exists in the incubation method. Since it is very difficult to maintain strictly the closed system in the test tube, the injector method which the writers use in gas determination is more recomendable, as shown in Fig. 1, B.

3. Determination of sulfide

Suzuki and Shiga⁶⁾ described the analytical method of sulfide. Since they used air as the agent to expell the hydrogen sulfide, Zn-powder which produces nascent hydrogen was used to prevent the oxidation by air. But, even in this case, the oxidation by air could not be avoided. The writers use nitrogen gas

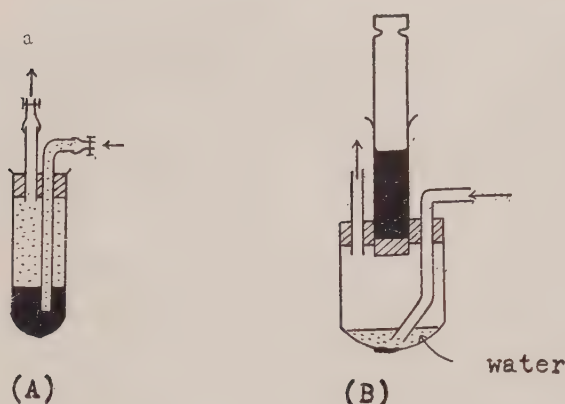


Fig. 1. Determination of free hydrogen sulfide

instead of air in the procedure.

(i) Incubation method .

Soil (10 to 15 grams equivalent to oven dried soil) is placed in a large test tube (2.5 cm diameter and 20 cm high) and the test tube is filled with water and stoppered by a rubber and then incubated at 30°C.

(ii) Analytical procedure

In analysis a rubber stopper is replaced by a rubber stopper with three mouths as shown in Fig. 2. The rubber stopper has three glass tubes. (a) is the route of hydrogen sulfide evolved from soil and (b) is used for introducing acid and Zn powder, and (c) is a long tube which can be moved up and down easily and is used to introduce nitrogen gas. To prevent the escape of hydrogen sulfide from the slit between glass tube and rubber wall, liquid paraffin is placed on the rubber stopper.

Nitrogen gas is introduced through (a) and most of the supernatant water is ejected through (c) and absorbed into lead acetate solution, and so sulfide in the water can be measured by usual iodometry.

And then (a) is connected to two drop catchers in order to carry hydrogen sulfide to the lead acetate (about 50–75 ml) and (c) is connected to a nitrogen bomb through the flowmeter and a gas washer which contains alkaline sodium hydrosulfite as shown in Fig. 3.

Five grams of Zn-powder and 10 ml of 20 per cent HCl (or 20 ml of 10 per cent HCl) are introduced through (b). Violent evolution of hydrogen sulfide and nascent hydrogen occur in the tube. Introducing nitrogen through (c), glass tube fitted at (c) is inserted gradually downwards and at last into the soil mud. Take care that the bubbling of nitrogen is not stopped by the soil. Nitrogen is introduced for 50 minutes at the rate of 700 ml per minute and hydrogen sulfide formed in the test tube is introduced to lead acetate through (a) and two drop catchers. And then sulfide in lead acetate is determined by usual iodometry as previously mentioned.

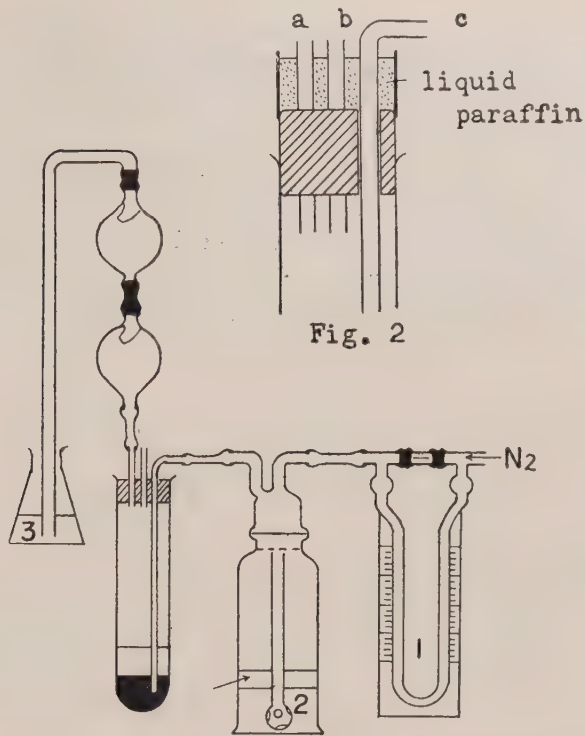


Fig. 3. Sulfide determination

1: flow-meter 2: gas washer 3: absorbent

(iii) Some discussion.

(a) Time of degassing. Driving time of nitrogen gas required for satisfactory results is different from soils. Twenty to 30 minutes are enough to drive hydrogen sulfide in the case of mineral soil having organic matter less than 5 per cent. But, in the case of muck soil which the writers use, 50 minutes are required to obtain the stable value. Twenty minutes of degassing can drive 50 per cent of hydrogen sulfide, 40 minutes can drive 80 per cent and 50 minutes can drive 100 per cent in the case of muck soil.

(b) Concentration of acid. With increasing acid concentration, hydrogen sulfide evolved increases gradually. Ten ml of 20 per cent of HCl or 20 ml of 10 per cent HCl are adopted because an almost stable value can be obtained by this concentration of acid. It is considered that sulfide is the mixtures from the unstable form such as hydrogen sulfide to the stable form such as pyrite. With increasing the concentration of acid and the driving time of nitrogen, hydrogen sulfide evolved increases. And so the writers do not know whether sulfide determined here contains all of pyrite.

(c) Use of Zn-powder. Nascent hydrogen produced by the reaction of Zn with acid can reduce thiosulfate, sulfite, rhodan salt and colloidal sulfur which are not

considered to exist in soil, but can not reduce sulfate. Though the writers use Zn-powder in this paper according to Suzuki and Shiga,⁶⁾ Zn-powder may not be required for this analysis in the case of the use of nitrogen gas instead of air. But the writers have not examined this test.

(d) Use of injector. As mentioned in the determination of free hydrogen sulfide, the injector method is more recommendable than the test tube method. There are some problems in determination of sulfate and sulfide to get an accurate value. But, as shown in Fig. 4 and Table 3, sulfate can be recognized to be converted almost to sulfide. And so the analytical method adopted here can be approved in the writers' experiment.

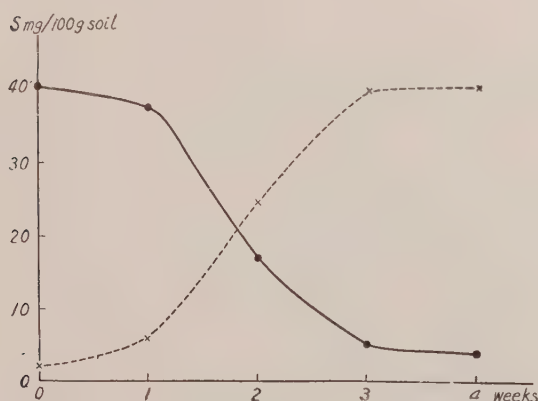


Fig. 4. Decrease of sulfate-S and increase of sulfide-S (muck soil + 20 mg sulfate-S)

III. Experiment (2)- Role of easily decomposable soil organic matter in the reduction of sulfate to sulfide

1. Idea

In order to clarify the role of easily decomposable soil organic matter, the writers compared the two kinds of soils, namely, one is the soil having abundant easily decomposable organic matter and the other is the soil having but little. And so it is desirable that both soils have the same characteristics as possible except the amount of the easily decomposable soil organic matter.

Using two soils having abundant decomposable organic matter, the writers wished to decrease the easily decomposable organic matter as much as possible and the following treatments were carried out.

Soils used for this treatment are muck paddy soil and sandy paddy soil. Both soils evolve free hydrogen sulfide in the field, especially vigorously in the midsummer. Characteristics of both soils are shown in Table 1.

Muck soil has a great deal of soil organic matter, i.e. decomposable organic matter and organic colloid. On the other hand, sandy soil has only a small amount of soil organic matter, but has a great deal of decomposable organic matter.

Table 1a. General characteristics (I) Texture

	coarse sand	fine sand	silt	clay	
muck soil	4.0	25.1	49.1	21.8	silty clay loam
sandy soil	47.5	39.2	7.8	5.5	loamy sand

Table 1b. General characteristics (II) hot HCl soluble portion

	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	P ₂ O ₅	CaO	MgO	K ₂ O	silica-alumina ratio
muck soil	11.95%	4.31	2.73	0.132	0.81	0.14	0.14	4.70
sandy soil	4.63	3.56	1.91	0.039	0.81	0.25	0.13	2.20

Both soils are treated as follows. Both air dried soils are incubated at 25–30°C for one month under the moisture condition of 50–60 per cent of the maximum water holding capacity. Then both soils are dried in atmospheric air, and then incubated under the same moisture conditions again. The soils which are incubated three times and six times, respectively, are prepared and are called three months treated soil and six months treated soil. Under these incubations easily decomposable organic matter decreased a great deal by oxidative decomposition, and the following kinds of soils are prepared.

	decomposable organic matter	organic colloid	samples
I	abundant	abundant	muck paddy soil
II	abundant	little	sandy paddy soil
III	little	abundant	muck soil with treatment
IV	little	little	sandy soil with treatment

Changes of characteristics by these treatment are shown in Table 2.

Table 2. Change of characteristics by pre-treatment

Sample	PH	T-C	T-N	NH ₄ -N	NO ₃ -N	SO ₄ -S	S ^o -S
		%	%	mg/100g soil			
muck soil non-treated	5.12	14.31	0.978	2.3	3.5	20.5	3.3
" 3 months treated	4.52	14.12	0.972	1.4	36.4	23.2	0
" 6 months treated	4.45	13.69	0.967	0.6	42.2	19.2	0
sandy soil non-treated	5.79	2.31	0.255	0.3	tr.	3.3	2.5
" 3 months treated	4.90	2.20	0.244	tr.	7.7	9.7	0
" 6 months treated	4.70	2.18	0.240	tr.	9.7	9.2	0

2. Experimental method

Na₂SO₄ is added to soils in test tubes and then the tubes are filled with water and tightly stoppered and incubated at 30°C. After incubation for a definite period

sulfate and sulfide are determined.

A small test tube and a large tube are prepared respectively for determination of sulfate and sulfide of each sample. For determination of Eh and pH, other tubes are prepared as shown in the previous paper.³⁾

Sulfate added are 0, 2, 4 mg-S to 10 g soil (oven dried basis). Since soils contain originally a certain amount of sulfate, sulfate in the sample is the sum of both sulfate.

3. Result

Result obtained are shown in Figures 5 – 8 and Table 3.

i) Eh_7 and pH

In non-pretreated soils Eh falls very rapidly and reaches the ultimate value within two weeks. But pretreated soils have slow falls of Eh and their reductive condition seems not to be developed.

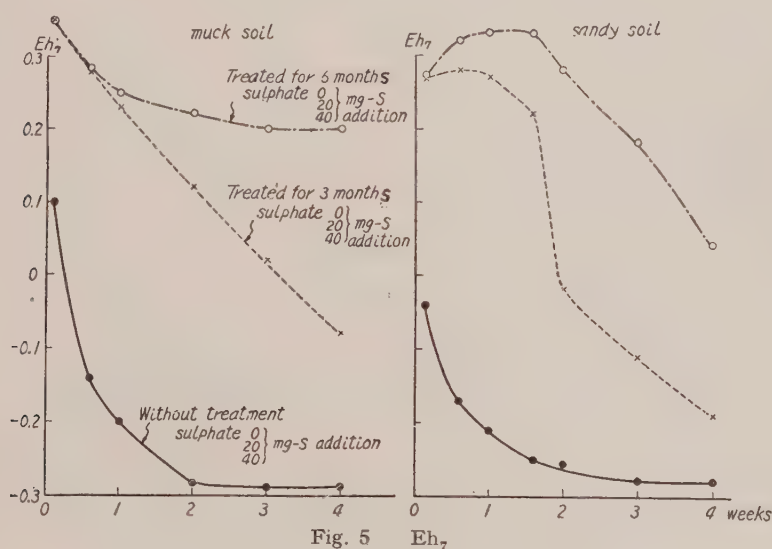


Fig. 5

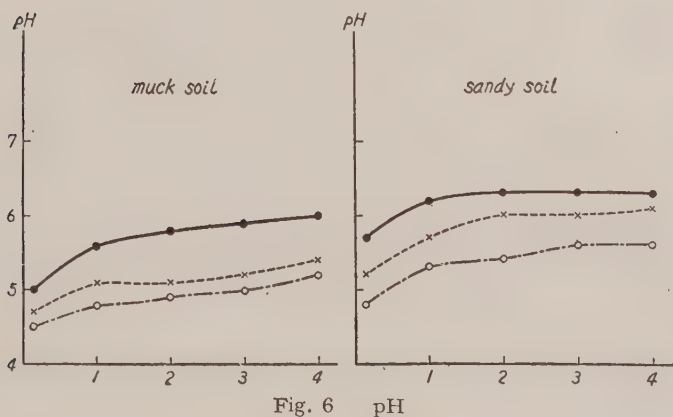


Fig. 6

Pretreated soils have lower pH values than non-pretreated soil during the period of incubation.

Addition of sulfate does not have any influence on the curve of Eh₇ and pH.

(ii) Sulfate-S and sulfide-S

Sulfate decreases rapidly and sulfide (containing hydrogen sulfide) increases rapidly in the case of non-treated soils, independent on the addition of sulfate and the kind of soil. On the other hand, it can be said practically that in pretreated soils only a small amount of sulfate decreases and sulfide increases.

As shown in Table 3, the sums of sulfate-S and sulfide-S are equal in all cases within the experimental error. This shows that sulfate is converted to sulfide quantitatively in the developing process of reductive condition in flooded soils. Some data which is noted by a question mark shows lower values. Its reason is in the lower value of sulfide due to the unsuitableness of the incubation method, and so the injector method should be adopted for eliminating this kind of error.

Table 3. Sulfate-S and sulfide-S (S mg/100g soil)

	SO ₄ -S added	form of S	initial	after 1 week	after 2 weeks	after 3 weeks	after 4 weeks
Muck soil (non-treated)	0	SO ₄ -S	20.5	17.7	3.0	0	0
		Sulfide-S	3.3	5.5	18.5	21.4	15.8
		sum	23.8	23.2	21.5	21.4	15.8(?)
	20	SO ₄ -S	40.5	37.5	17.0	5.3	4.2
		Sulfide-S	3.3	6.0	24.6	39.8	40.1
		sum	43.8	43.5	41.6	45.1	44.3
Sandy soil (non-treated)	40	SO ₄ -S	60.5	56.9	19.3	5.5	4.9
		Sulfide-S	3.3	6.9	37.7	51.4	57.1
		sum	63.8	63.8	57.0(?)	56.9(?)	62.0
	0	SO ₄ -S	8.4	4.0	0	0	0
		Sulfide-S	2.5	6.9	8.7	9.3	4.4
		sum	10.9	10.9	8.7	6.3	4.4(?)
Sandy soil (non-treated)	20	SO ₄ -S	26.4	18.8	11.0	4.9	4.1
		Sulfide-S	2.5	11.6	19.2	24.4	24.3
		sum	30.9	30.4	30.2	29.3	28.4
	40	SO ₄ -S	48.4	38.4	16.9	5.1	4.6
		Sulfide-S	2.5	11.8	32.9	42.2	44.0
		sum	50.9	50.2	49.8	47.3	48.6

Decrease of sulfate and increase of sulfide proceed rapidly in the second week and reached the maximum within three weeks. This phenomena proceeds together with the development of the reductive condition of soils. One week after incubation, the reductive condition is developed and then the sulfate reducer can work actively in the soil.

In the case of pretreated soils the reductive condition can not be developed within four weeks studied and so only a slight decrease of a sulfate and increase of sulfide can be recognized. In some cases of non-pretreated soil, for example, in the

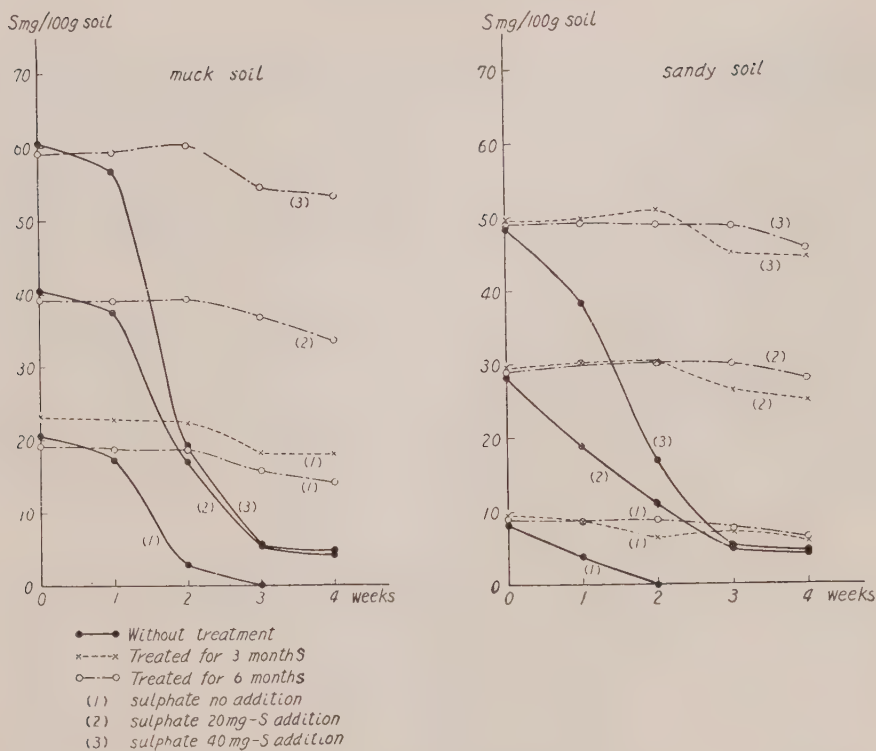


Fig. 7 Sulfate-S

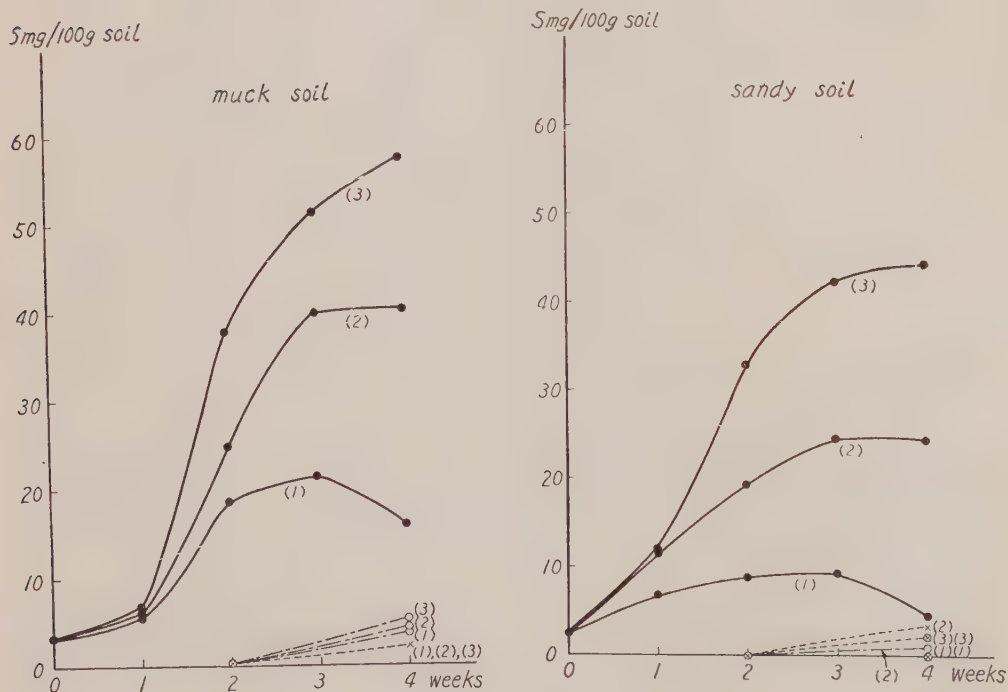


Fig. 8. Sulfide-S (Containing hydrogen sulfide)

case of the addition of sulfate, sulfate can not reach the zero value after four weeks. Though some reasons of this phenomena can be considered, it can not be decided which is the cause, the unsuitableness in the incubation method, the oxidation effect of added sulfate, or the use of aqua regia in analysis.

IV. Role of soil organic colloid in the effect of added iron oxide on preventing the formation of free hydrogen sulfide

1. Idea

The writers found little effect of iron oxide to prevent the evolution of free hydrogen sulfide in the muck paddy field, and they thought that the complex formation of soil organic colloid with iron oxide decreases the preventing effect of iron oxide. And so the writers wished to make this phenomena again in laboratory condition.

2. Experimental method

Muck paddy soil and sandy paddy soil (non-pretreated soil) are used for this experiment. Sandy soil has only a small amount of organic colloid. Iron oxide used is made from FeCl_3 . NaOH is added to acidic solution of FeCl_3 until pH 7.0 and precipitate of iron hydroxide are washed by water and electro-dialyzed, and then dried at 60°C .

To 10 g soil (equivalent oven dry basis) in test tube are added 0, 50, 100, 200 and 500mg of iron oxide. After mixing, 2mg of $\text{Na}_2\text{SO}_4\text{-S}$ is added and then the test tubes are filled with water and incubated at 30°C . After a definite period sulfide and free hydrogen sulfide are determined. Eh_7 and pH are also measured.

3. Results

(1) Eh_7 and pH.

Addition of iron oxide has no effect on the curves of Eh_7 and pH of the original soil. It should be noted that this phenomena shows a large capacity of reductive state of both soils. If the capacity of reductive state is small even in the case of low Eh which is an intensity of reductive state, the addition of iron oxide must bring the higher value on the Eh-time curve, namely, iron oxide can oxidizes the reductive state. And so it is considered that the addition of iron oxide does not retard the reduction of sulfate in this experiment.

(ii) Sulfide (containing hydrogen sulfide).

Determination of sulfide is shown in Table 4. In both soils, the addition of iron oxide does not have any effect on the reduction of sulfate to sulfide.

(iii) Free hydrogen sulfide.

Data are shown in Table 5.

The addition of iron oxide decreases the formation of free hydrogen sulfide. Though this phenomena is remarkable in sandy soil, in muck soil only a little decrease can be recognized, notwithstanding that muck soil has much more iron

Table 4. Sulfide (S mg/100g)

soil	Fe ₂ O ₃	1 week	2 weeks	3 weeks	4 weeks
muck soil	0 %	6.0	24.6	39.8	40.1
	2.0	5.8	24.6	39.8	40.2
	5.0	5.9	25.9	39.8	40.1
sandy soil	0	11.6	19.6	24.4	24.4
	2.0	11.5	19.6	24.4	24.4
	5.0	11.6	19.5	24.4	24.4

Table 5. Hydrogen sulfide (S mg/100g)

soil	Fe ₂ O ₃	1 week	2 weeks	3 weeks	4 weeks
muck soil	0 %	1.44	0.71	0.52	0.59
	0.5	1.08	0.47	0.39	0.34
	1.0	0.98	0.35	0.17	0.18
	2.0	0.54	0.17	0.15	0.07
	5.0	0.26	0.11	0.06	0.06
sandy soil	0	1.05	0.67	0.30	0.16
	0.5	0.14	0.08	0.04	0.04
	1.0	0.10	0.04	0.02	0.02
	2.0	0.07	0.03	0.02	0.02
	5.0	0.03	0.03	0.03	0.01

(Fe₂O₃ soluble in hot HCl: 2.7%) than sandy soil.

In order to make clear the effect of iron, in Fig. 9 are shown the percents of free hydrogen sulfide as compared with that of no addition of iron oxide. In sandy soil the 0.5 per cent addition of iron oxide stops practically the formation of free hydrogen sulfide, while in muck soil the addition of iron oxide shows only a little effect.

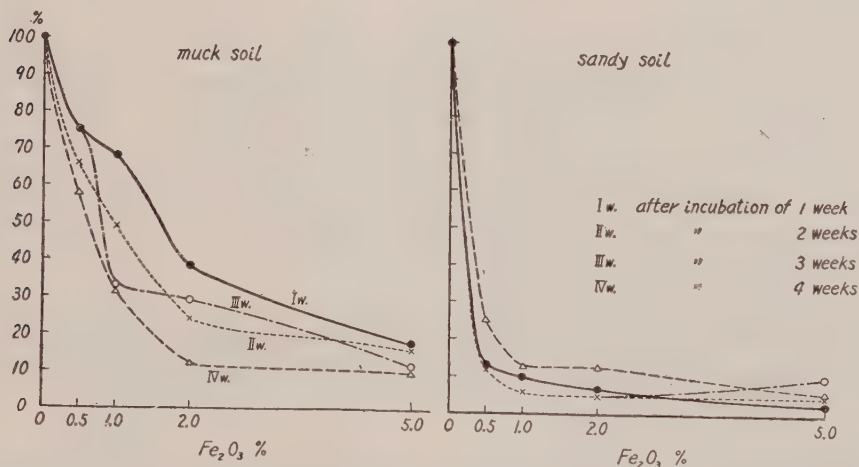


Fig. 9. Rate of evolution of free hydrogen sulfide and the influence of iron oxide.

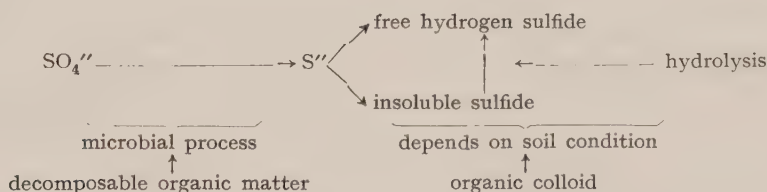
V. Discussion

1. Rapid decrease of sulfate and rapid increase of sulfide can be recognized in the non-treated flooded soil. On the other hand, the reduction of sulfate is retarded remarkably in the case of the pretreated soil which has only a small amount of easily decomposable organic matter.

Through the decomposition by soil microorganisms, easily decomposable organic matter can make the reductive condition suitable for the action of sulfate reducer, multiply the sulfate reducer and produce the organic compounds as the hydrogen donor to sulfate reducer.

2. In muck soil which has much soil organic colloid, the addition of iron oxide has a little effect on the prevention of the formation of free hydrogen sulfide. Precipitation of iron sulfide is retarded by the formation of iron-organic complex or other kinds of interference by organic colloid.

3. The process from sulfate to the evolution of free hydrogen sulfide can be divided into two stages, namely, the reduction of sulfate to sulfide is carried by the sulfate reducer but whether sulfide is changed to insoluble sulfide such as iron sulfide or to free hydrogen sulfide depends on the soil condition such as the interrelation of sulfide, active iron and organic colloid. Among soil organic matter, easily decomposable organic matter takes a part in the reduction of sulfate and organic colloid takes an important role in whether hydrogen sulfide is caught by iron compound or exists in free form.



4. Reduction of sulfate is done by the action of the strict anaerobe. There is a danger that the pretreatment of soils before flooding gives the inhibitory effect to sulfate reducer too much to work actively under flooded condition even in the case of the existence of a great deal of decomposable organic matter. Sulfate reducer exists in the field except paddy field. By means of the addition of sugar to the pretreated soil, hydrogen sulfide is actively formed under flooded condition. And so the reason of the little formation of sulfide in the pretreated soils can not be due to the inactivation of sulfate reducer, but due to the lack of the easily decomposable organic matter.

Summary

In muck paddy soil, the addition of iron compound had little effect on preventing the formation of the free hydrogen sulfide. This phenomena seemed to

be due to the great deal of soil organic matter, especially the organic colloid. And so the writers attempted to clarify the role of soil organic matter, which is divided into two categories, on the process from sulfate to free hydrogen sulfide. Results obtained are as follows.

(1) Since there are no adequate method for determination of sulfur compound, suitable methods are tested for analysing sulfate, sulfide and free hydrogen sulfide.

(2) By pretreatment, soils having little decomposable organic matter are prepared.

(3) After flooding, rapid decrease of sulfate and rapid increase of sulfide can be recognized in non-treated soils having a great deal of decomposable organic matter, while a little decrease of sulfate and a little increase of sulfide can be obtained in the pretreated soils.

(4) Addition of iron oxide has a great effect on preventing the formation of free hydrogen sulfide in sandy soil having little organic colloid, while little effect in muck soil having a great deal of organic colloid.

(5) It can be considered that the decomposable organic matter takes a part in the sulfate reduction and the organic colloid plays an important role in the evolution of free hydrogen sulfide.

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Studies on the *Helminthosporium* Leaf Blight of Rice Plant

Part 4. Conidia formation on the blight lesion

Teruko ÔMATSUZAWA, Katsumi SATO and Masayuki SAKAMOTO

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I. Introduction

Generally speaking, the infectivity of an air-borne plant disease may be determined by both the rate and the abundancy of spore production by the pathogen on lesion. Spore dispersing from a certain lesion may settle upon a host-tissue, then invades into it, and, sooner or later, spores will be formed again on this new lesion. Thus reinfection may begin. This process can be considered as one of those consecutive links which comprise infection chains of the pathogen in the field. Consequently, the shorter the time for completion of each link is and also the more abundant the spore production is, the more the disease rages. The authors noticed in the previous paper that *Helminthosporium* leaf blight might be an endemic disease in its character, viz., its habitual occurrence was restricted exclusively to such a particular paddy field as muck, peat or degraded one. And it was further suggested that such restriction would be derived mainly from continuity of the infection chains of the blight fungus.

About 40 years ago Suematsu,¹⁶⁾ and recently Fukatsu and Kakizaki¹⁾ also reported that the blight conidia were formed within a short period under favorable conditions. The authors also observed frequently that they were produced abundantly on diseased leaves within only one night's incubation in moist chamber.

Increased floating of the blight conidia in the muck paddy field since late August was already reported¹⁰⁾. In certain preliminary observations carried out from late July to early August, it was found that the blight lesions collected from the field formed only rarely a few conidia or did not at all. It was usually observed that a small lesion occurred by an artificial inoculation at early growth stage did not form any conidia. As early as 1928 NISHIKADO noticed in his monograph on the graminicolous *Helminthosporia* in Japan⁴⁾ that the conidia formation occur-

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red at a central part of large lesion or on the lesion upon dead part of leaf. Recently Fukatsu and Kakizaki¹¹ also reported that, on living leaves, II type lesion formed conidiophores only rarely and III type did them abundantly, while the former was just able to produce them after death of the leaf.

Although a few lesions could usually be found, by a close inspection, sparsely on the lower leaves of ordinary paddy plants, no further spreading occurred at all. In case of artificial inoculation, however, the present fungus was able to attack rice plants nearly throughout their growth.

The facts above mentioned may imply that the formation of the blight conidia on lesions varies remarkably according to the difference of lesion-type and the physiological state of infected leaf. In 1959, in order to ascertain the above implication a systematic examination was made on sporulation of the blight lesions produced by artificial inoculation at various growth stages of the rice plants. The results are given in the present paper.

II. Materials and methods

As rice plants are always exposed to the blight attack throughout their growing period in the field where the disease usually prevails, there would be found, even on the same leaf, various types of lesions which had been formed at different times. So it may be unreasonable to compare them indiscriminately with the spore-forming ability of each lesion. The present observations were made mainly on the lesions formed by an artificial inoculation at definite times during the growing period of rice plants.

1. Test plants

Two rice seedlings were grown in Wagner's pot (ca. 1/50000 are). Soils: ordinary and muck paddy soils, 2.3kg per pot. Fertilizer: ammonium sulfate 3.0g, superphosphate 3.3g and potassium chloride 1.0g (control plants) or 0g (potassium deficient plants) per pot as basal dressing. Sowing: April 11, 1958. Transplanting: June 1. Culture condition: daytime at outdoor, and rainy day or night in a glass house. *Norin No. 16* variety was used.

2. Inoculum

The same blight strain as that described in the previous paper was employed as an inoculum. It was cultured on Richards' agar medium* and after seven days' incubation at 23°-25°C, the conidiospores produced were collected. Spore suspension of a definite concentration was applied to the test plants by an atomizer. After 12-13 hours' incubation (23°-25°C) in a moist chamber the inoculated plants were placed in a glass house.

3. Method of observation

* Sucrose: 30 g/l.

Diseased leaves were cut in 10 cm length. Lesions on them were assigned respectively to each type of lesion, and marked with paint. After formation of conidiophores and conidia were examined under a microscope, the leaf-surface was thoroughly wiped with a clean wet gauze. Several leaves (3-6) were arranged in parallel and fixed with cellophane tapes at their both ends. They were incubated in a moist chamber at the temperature around 25°C.

Conidia formation (occurrence, rate, abundancy, and location where they were formed, *etc.*) of all the lesions under test was microscopically examined every day during incubation. The change of leaf-coloration during incubation was also noticed.

*The type of lesion*¹⁾: A type: minute brown spot without a venenate zone or with light yellowish narrow band around a necrotic part. B type: typical blight lesion of medium size, sometimes more than 3mm in length, with a clear-cut necrotic part and a venenate zone. C type: lesion of medium size, with a clear-cut blackish-brown necrotic part and without a distinct venenate zone. D type: lesion of large size (over 3 mm), with gray degenerated part at the center, sometimes irregular shape with speckled marking or concentric rings.

Conidia production: In the tables of the next chapter, - indicates no sporulation, and \pm , +, and ++ indicate the sporulating degrees in increasing order.

Leaf color: In the tables of the next chapter the leaf color is described as that in parenthesis for simplicity; Green (G), light green (IG), yellowish green (yG), greenish yellow (gY), yellow (Y), brownish yellow (bY), brown (B), dark green (dG), dark greenish brown (dgB), and dark brown (dB). As will be mentioned later, leaves of muck paddy plants, especially of potassium-deficient ones, showed dark brown or brown color in their necrobiotic process during the incubation period.

From early July to middle September in 1958 seven observations were carried out, but the results of five observations among them will be given in the present paper. The remaining two observations showed similar results. Dates of inoculation and sampling, and duration of incubation for each observation are shown in the following table.

No. of observation	Date of		Days from inocul. to sampling	Duration of observation
	inoculation	sampling		
I	July 13-14	July 29	17	July 29 - Aug. 4
II	July 22-23	July 31	8	July 31 - Aug. 8
III	Aug. 6-7	Aug. 15	9	Aug. 15 - 25
IV	Aug. 6-7 Aug. 6-10	Aug. 19	12 9	Aug. 19 - 27
V	July 30-31 Aug. 1-2	Aug. 22	22 19	Aug. 22 - 29
VI	Aug. 18-19	Aug. 2	7	Aug. 26 - Sept. 2
VII	Aug. 18-19	Sept. 26	14	Sept. 2-10

III. Results of the observations

Observation I

Inoculation : July 13–14. Sampling : July 29. Observation : July 29–Aug. 4 (6 days). Incubation temperature : 27°C. On the sampling day the 14/0 leaves (the booting leaf on a main haulm) of the control plants grown in ordinary paddy soil were unfolding ; and no lesion on the 14/0 and 13/0 leaves. The 13/0 (uppermost) leaves of the other plants (potassium-deficient, ordinary paddy plants, and control muck paddy plants and potassium-deficient, muck paddy plants) were unfolding ; and no lesion was found on the 13/0 and 12/0 leaves.

Results are shown in Table 1.

Table 1

Leaf position (No. of leaves)	Lesion type, (number, observed)	Sporulation & leaf color	Duration of observation (day)							
			* 0	1	2	3	4	5	6	
a. Control ordinary paddy plant										
11/0 (2)	A (8)	l. c.	G	1G	gY	gY	gY	Y	Y	
10/0 (2)	A (7)	l. c.	G	1G, yG	gY	gY	gY	Y	Y	
9/0 (2)	A (9)	± + l. c.	G	1G, yG	gY	Y	Y	2 Y	2 Y	
b. Potassium-deficient, ordinary paddy plant										
11/0 (2)	A (10)	l. c.	G	G	yG	gY	gY	Y	Y	
10/0 (2)	A (11)	l. c.	G	yG	gY	gY	gY	Y	Y	
9/0 (2)	A (7)	± l. c.	G, gY	gY, Y	Y	Y	Y	2 Y	3 Y	
c. Control muck paddy plant										
11/0 (2)	A (3)	l. c.	G	G	G	yG	yG	gY	gY, Y	
10/0 (2)	A (9)	l. c.	G	G	yG, gY	gY	gY	Y	Y	
9/0 (1)	A (2)	l. c.	G	G	yG	gY	gY	Y	Y	
d. Potassium-deficient, muck paddy plant										
11/0 (1)	A (2)	l. c.	G	G	G	G	G	yG	gY	
10/0 (2)	A (4)	l. c.	G	G	G	1G	gY	Y	Y	
9/0 (2)	A (10→7) B (0→3)	± ± + l. c.	G	↘** G	G	1G, gY	1 gY, Y	1 2 Y	2 Y	

* : sampling day.

** : transition of lesion type.

Observation II

Inoculation : July 22–23. Sampling : July 31. Observation : July 31–Aug.

8 (8 days). Results are shown in Table 2.

Table 2

Leaf position	Part of leaf	Lesion-type (number, observed)	Sporulation & leaf color	Duration of observation (day)									
				0	1	2	3	4	5	6	7	8	
a. Control much paddy plant (booting leaf=13/0)													
12/0	tip middle base	A (7) A (6) A (4)	l. c. l. c. l. c.	G G G	G G G	G G G	G G G	lG lG G	lG yG G	gY yG G	gY yG lG	Y Y gY	
11/0	tip middle base	A (7) A (9) A (6)	l. c. l. c. l. c.	G G G	G G G	G G G	gY gY G	Y Y yG	Y Y gY	Y Y gY	Y* Y* gY	Y** Y** Y	
10/ 0	tip middle base	A (4) A (4) A (2)	l. c. l. c. l. c.	G G G	G G G	G G G	gY gY gY	Y Y Y	Y Y Y	Y Y Y	Y* Y* Y	Y** Y** Y	
9/0	tip	A (5)	± + # l. c.								*	**	
	middle	A (7)	± + # l. c.								*	**	
	base	A (3)	± + # l. c.								*	**	
b. Potassium-deficient, much paddy plant (booting leaf=14/0)													
12/0	tip	B (7→0)									**		
		D (0→7)	± + # l. c.	G	G	G	yG	1 5 gY, bY	2 5 gY, bY	7 bY	bY	bY	
	middle	A (3→2) B (5→0) D (0→3)	l. c.	G	G	G	yG	yG, gY	gY	Y	***	**	
	base	A (4)	l. c.	G	G	G	G	G	yG	gY	Y	Y	
11/0	tip	?	l. c.	B (died)**									
	middle	B (9→3)	± + #					*** 3	** 6				
		D (0→6)	± + # l. c.	G	G	gY	bY	1 5 bY	*** 6 bY	** 6 B	B	B	B

Table 2 (continued)

	base	A (2→1)	± + +						1	1	**	**
		B (4→0)	± + +						1	1		
		D (0→4)	± + + l. c.	G	G	G	gY, Y	bY	4 bY	4 B		
10/0		?	l. c.	B (died)**								
9/0		?	l. c.	B (died)**								

* Conidia were formed sparsely at a part distant from the lesion ; ** formed abundantly all over the leaf-surface ; *** formed abundantly at the part where many lesions were located densely.

Observation III

Inoculation : Aug. 6-7. Sampling : Aug. 15. Observation : Aug. 15-25 (10 days). Booting leaf=15/0. The leaves of tillers were used for observation (the uppermost leaf=No. 1). Results are shown in Table 3.

Table 3

Leaf position (No. of leaves)	Lesion type (number, observed)	Sporulation & leaf color	Duration of observation (day)									
			1	2	3	4	5	6	7	8	9	10
a. Control muck paddy plant												
No. 1 (5)	A (12)	± + l. c.	G	G	G	G	lG, yG	lG, yG	lG, yG	yG, gY	gY, Y	1 Y, by
No. 2 (5)	A (23)	± + + l. c.	G	lG, G	G, lG, yG	G, gY	gY, Y	gY, Y	Y	1 Y, bY	4 4 3 Y, bY	1 5 9 Y, bY
No. 3 (5)	A (42)	± + + #					3	8	16	31	12 20	8 26
	B (3)	± + + l. c.	G	G, lG	G, yG	yG, gY	gY	gY	1 1 Y	2 Y, bY	2 1 Y, bY	2 1 Y, dB

Table 3 (continued)

No. 4 (5)	A (19)	± + +					9 2	12	1 16	**		
	B (3)	± + + l. c.	G, lG	lG, yG	gY, Y	Y	Y, bY	2 bY	3 bY			
No. 5 (5)	A (10)	± + +				1	1 4	8 2	10	**		
	B (2)	± + + l. c.	yG, gY	gY, Y	gY, Y	bY	2 bY	2 bY	2 bY			
b. Potassium-deficient, much paddy plant												
No. 1	A (10) B (6)	l. c.	G	G	G	G	G, lG yG	G, lG yG	lG, yG, Y	yG, Y gY, Y	gY, Y Y, bY	Y, bY
No. 2 (5)	B (30)	± + +	7 3	9 6	7 16	3 13 8	7 12 11	1 18* 11	10** 20	4 26	4 26	4 26
	D (2)	± + + l. c.	G	1 1 G, lG	2 G, lG, gY	2 dyG, bY	2 dgY, B	* 2 dY, dgB	** 2 dgB	2 dgB	2 dgB	2 dgB
No. 3 (5)	A (1)	± + +			* 1	** 1	1	1				
	B (34)	± + + l. c.	4 17 G	5 11 7 G, dlG	5 4* 20 yG, dgY	13** 20 dgB	2 31 dgB	3 31 dgB	34 dgB	dgB	dgB	dgB
No. 4 (5)	A (2)	± + +							2 **	2	2	
	B (34)	± + + l. c.	10 5 G	9 6 yG, gY, Y	5 15 gY, B, dB	19 9 B, dgB	23 9 dB, dgB	8 25 dB, dgB	33 dgB	33 dB, dgB	33 dB, dgB	dB, dgB
No. 5 (3)	B (10)	± + + l. c.	3 yG	3 4 dY	2 7 B	3 7 B, dgB	10 dB	** 10 dB	10 dB	10 dB	dB	dB

* Conidia were produced almost all over the surface; ** produced all over the surface.

Observation VI

Inoculation : Aug. 18-19. Sampling : Aug. 26. Observation : Aug. 26-Sept. 2 (7 days). The leaves of tillers were used for observation (the uppermost leaf=

No. 1) Results are shown in Table 4.

Table 4

Leaf position	Part of leaf	Lesion type (number, observed)	Sporulation & leaf color	Duration of observation (day)								
				0	1	2	3	4	5	6	7	
a. Control muck paddy plant												
No. 1	tip middle	A (7) A (5)	l. c. l. c.	G G	G G	G G	G G	yG yG		gY yG	gY yG	
No. 2	tip middle	A (8) A (9)	l. c. l. c.	G G	G G	G G	yG yG	gY yG		Y gY	Y Y	
	base	A (4)	± l. c.	G	G	G	G	yG		gY	1 Y	
No. 3	tip	A (8)	± + #					1 1		7 ***	8	
		B (15)	± + # l. c.	G	G	G	gY	gY		14 yB	15 dB	
	middle	A (3)	±								1	
		B (2)	± + # l. c.	G	G	G	yG	gY		2 Y	2 B	
	base	A (3)	± +								1 1	
		B (2)	± + # l. c.	G	G	G	yG	yG		gY	1 Y	
	No. 4	tip	B (10)	± + # l. c.	gY	B	B	B	** dB		dB	dB
		middle	A (1)	± + #				1	1		1	**
B (7)			± + # l. c.	G	yG	gY	B	B		B	dB	
base		A (1)	± +								1 ***	
		B (3)	± + # l. c.	G	G	gY	gY	Y		1 2 B	3 dB	

b. Potassium-deficient, muck paddy plant

Table 4 (continued)

No. 1	tip middle	A (3) A (2)	l. c. l. c.	G G	G G	G G	G G	yG G		gY lG	Y gY
No. 2	tip	A (1)	±								
		B (9)	± + +				3 4	9		9	9
		C (1)	± + +				1	1		** 1	1
		D (3)	± + + l. c.		2 G	3 G	2 yG	3 1 yG		3 dgB	3 dgB
	middle base	A (13) A (3)	l. c. l. c.	G G	G G	G G	G G	yG yG		Y Y	Y Y
No. 3	middle	B (5)	± + +				1 4	5			
		D (9)	± + + l. c.			9 G	9 dG	9 dgB	*** dgB	dgB	dgB
	base	A (3)	± + +							3	
		B (1)	± + +				1	1	1	1	**
		D (2)	± + + l. c.		2 gY	2 gY	2 gY	2 dgY	2 dgY	2 dgB	dgB

** Conidia were produced all over the surface; *** produced abundantly at the part where many lesions were located densely.

Observation VII

Inoculation: Aug. 18-19. Sampling: Sept. 2. Observation: Sept. 2-10 (8 days). Booting leaf=13/0. Results are shown in table 5.

Table 5

Leaf position (No. of leaves)	Lesion type (number, observed)	Sporulation & leaf color	Duration of observation (day)								
			0	1	2	3	4	5	6	7	8
a. Control ordinary paddy plant											
13/0 (2)	A (9)	l. c.	G	G	G	G	G	yG, gY	yG, gY	yG, gY	Y

Table 5 (continued)

12/0 (3)	A (7)	l.c.	G	G	G, yG	G, yG	lG, yG	gY	gY	gY	gY, Y
11/0 (3)	A (9)	± +						2	2	1 2	1 4 **
	B (7)	± + + l.c.	G	G, lG	lG, gY	1 gY, B	2 3 yB, dB	1 1 5 yB, dB	7 yB, dB	7 dB	7 dB

b. Potassium-deficient, ordinary paddy plant

13/0 (3)	A (9)	± + l.c.	G	G	G	G	G	yG	yG	yG, dB	1 dB
12/0 (3)	A (10)	± + l.c.	G	G, lG	G, yG	yG	yG, gY	yG, gY	gY, gB	gB, B	1 B
11/0 (3)	A (3)	± + +					1	2	2	1 1 **	2
	B (18)	± + + l.c.	G	G, lG	yG, gY	4 1 gY, Y	14 gY, dB	1 1 16 dB	2 2 16 dB	2 2 16 dB	2 2 16 dB

c. Control much paddy plant

13/0 (5)	A (11)	± l.c.	G	G	G, yG	G, yG	lG, gY	yG, gY	yG, gY	yG, gY	1 gY, Y
12/0 (3)	A (7)	l.c.	G	G	G, yG	yG	yG, gY	yG, gY	gY, yB	yB, B	B
11/0 (3)	A (7)	± +					1 1	1 3	2 3 *	5 **	5
	B (13)	± + + l.c.	G	lG, gY	gY, Y	1 gY, bY	3 3 gY, dB	3 2 5 B, dB	6 5 B, dB	1 11 dB	1 11 dB

d. Potassium-deficient, much paddy plant

13/0 (2)	A (7)	l.c.	G	G	G	G	G, lG	yG	yG	yG	gY
12/0 (3)	A (5)	± +								1	1 3
	B (12)	± + + l.c.	G	G	G, yG	G, yG	1 2 gY, dB	4 dB, B	1 4 B, dB	2 2 4 dB, dB	4 4 dB, dB

Table 5 (continued)

11/0 (2)	A (4)	± +			2	3	3	3	3	3	4
	B (6)	± + +		1 1	1 1 2	2 2 2			** 5	1 5	1 5
	D (3)	± + + l. c.	G, bG	yG, gY	1 1 dgY	3 dgB	3 dgB	3 dgB	3 dgB	3 dgB	3 dgB

* Conidia were produced almost all over the surface ; ** produced all over the surface.

It was usual that various types of lesion occurred together on one and the same leaf even by an artificial inoculation and the proportion of their occurrences was varied according to the different growing stage of a host plant or different leaf age and also by the influence of soil conditions or fertilizers. It was sometimes found that those lesions which were located densely on some part of a leaf fused with each other. They were eliminated because of the uncertainty of distinguishing their types and also of evaluating their respective spore forming abilities. So the number of lesions in parenthesis in the above tables could not always indicate their actual number on the leaf under test. However, as careful attention was given to all the lesiontypes distributed on an infected leaf, the proportion among the numbers of respective types may be roughly considered as an actual ratio of their occurrences. For example, in Table 1 (a, b, c, and d) and also Table 2a, no other types excepting A did not occur ; and at later stage, as shown in Tables 4 and 5 (lower leaves), B and D types of lesion occurred much more frequently.

Growth stage of the test plant (*Norin No. 16* variety) was as follows: primordial, head-bearing and heading stages were July 18–20, August 14 and August 20–22, respectively. So the inoculation in Observation I was carried out before the primordial stage, and that in Observ. II was just at its primordial stage ; and those in Observ. VI and VII were made after the heading stage.

IV. Consideration and conclusion

1. Type of lesion

(i) Shift of type through the growing stage of a host plant.

It was previously reported⁸⁾ that B and D types which actively produce abundant conidia occurred after the primordial stage of the rice plant. Also in the present investigation all the lesions resulted from the first inoculation before the primordial stage were restricted exclusively to A type.

In the second inoculation at about the primordial stage a few lesions belonging to A type could be found only on the lower leaves. But, during incubation in a moist chamber, such a transition of lesion-type as A→B, B→D or A→B→D occurred.

Among them the B→D transition could be found most frequently. Such a transition could not be found on the leaves inoculated in August. It was interesting that these phenomena were found only on the diseased leaves by the inoculation at around the primordial stage, and after that a proportion of occurrences of various lesion-types should be expected to change as mentioned elsewhere.¹⁰⁾

In the third inoculation (August 6–7) rapid increasing of B type was found and in the sixth inoculation (August 18–19) that of D type was found especially on the lower leaves.

It can be said that the blight lesion becomes to enlarge rapidly after the primordial stage of the rice plant.

(ii) Leaf position on a haulm (leaf age) and lesion type.

On the rice plants inoculated after the primordial stage, A type of lesion occurred exclusively or mostly on the upper (young) leaves, while on the lower (mature or old) leaves both B and D types appeared most frequently (Tab. 3b, 4 and 5). It was shown previously¹⁰⁾ that the occurrence of large type of lesion (B, C or D) increased suddenly in the artificial inoculation applied after about seven days from a complete elongation of leaf and this was remarkable with a potassium-deficient muck paddy plant.

As for one leaf, B and D types appeared rather near to the tip of a leaf (tab. 4).

(iii) Influence of soil and potassium deficiency upon the lesion type.

In the first inoculation (July 13–14) all the lesions on both the ordinary and the muck paddy plants were found to belong to A type (Tab. 1); and even in later inoculation (August 18–19) B type slightly prevailed only on the 11/0 leaves of the latter plants (Tab. 5). Effect of muck paddy soil upon the lesion-type could not be recognized clearly with the pot-cultured rice plants. The result did not conform with that of the investigation on the blight occurrence in the field in 1954⁶⁾. The cause for such discrepancy remains to be proved. It may be pointed out, however, that certain discrepancy was also noticed in the nutritional research about different influences by both kinds of soil upon the growth of the rice plants grown in the pot and field.⁸⁾

Effect of potassium deficiency upon the lesion-type was not found in the early growth stage (Tab. 1 and 2); but on the leaves of muck paddy plants without potash the transition of lesion-type occurred during incubation (Tab. 1 and 2). In a later stage the effect was clearly shown in increased appearance of B type on the 12/0 and 11/0 leaves of muck paddy plants (Tab. 5c and d), and, though less remarkable, also on the 11/0 of ordinary paddy plants (Tab. 5a and b). It can be said that potassium-deficiency tends clearly to enlarge the blight lesion and this tendency is conspicuous in later growth stage of muck paddy plants, which will be seen clearly in Table 6, where the results of the present observations are summarized.

Table 6.

Soil	potash fertilizer	Total number of lesions, examined	Percentage of the occurrence of each type (%)			
			A	B	C	D
Ordinary paddy Soil	+	47	85	15	0	0
	—	59	69	31	0	0
Muck paddy Soil	+	297	80	20	0	0
	—	497	28	68	0.0	4

In the figure 2 of the previous paper (p. 113), a similar tendency is recognized in which nine artificial inoculation tests on the 13/0 leaves of ordinary and muck paddy plants with or without potash fertilizer carried out from late July to early September, and the results indicated that the proportion of occurrences of various types changed according to growth stage and potassium deficiency enlarged the blight lesion especially with the latter plants.

2. Conidia formation on the lesion

(i) Lesion-type and sporulating ability. Among 452 lesions of A type under test 175 lesions (35%) formed conidia slightly, among 405 of B type 387 (96%) and all lesions of D type formed them abundantly.

(ii) Leaf age and growth stage of a plant. Sporulating degree of the blight lesions, though they might belong to the identical type, varied according to different growth stage of a host plant or leaf age. A type lesions occurred in the early stage or on upper (young) leaves did not form conidia or, if any, did scantily; while those in later stage or on lower (old) leaves, especially those which coexisted with B or D type lesions, tended rather easily to form conidia. Such tendency is seen clearly in Tables 1, 2, 3, 4, 5 and 7.

Table 7. Spore formation of A type lesion on the 11/0 leaves occurred in different growth stage

Soil	Potash	I (inoculated on July 13-14)		VII (inoculated on August 18-19)	
		lesions, observed	lesions, formed conidia	lesions, observed	lesions, formed conidia
Ordinary paddy soil	+	8	0	7	5
	—	10	0	4	3
Muck paddy soil	+	3	0	9	7
	—	2	0	3	2

Furthermore the time required to form conidia on A type-lesions prolonged on the upper (young) leaves or in the early growth stage of a plant. Even with

B type this was seen clearly; for example, those produced in late July required 4-5 days for their conidia formation, while those in late August required 1-4 days. D type lesions produced them after only one day's incubation.

(iii) Effect of soil and potassium deficiency. Results are summarized in Table 8.

Table 8. Percentage of the lesions of each type which produced conidia to the total lesions

Soil	Potash	Total lesion			A type			B type			D type		
		No.	Number, formed conidia	%	No.	Number, formed conidia	%	No.	Number, formed conidia	%	No.	Number, formed conidia	%
Ordinary paddy soil	+	47	14	30	40	7	18	7	7	100	--	—	—
	—	59	24	41	41	6	15	18	18	100	—	—	—
Muck paddy soil	+	297	170	57	237	110	42	60	60	100	—	—	—
	—	496	398	80	134	54	40	360	302	94	42	42	100

Most of B type lesions produced conidia regardless of soil conditions or of potassium deficiency. All the lesions of D type produced them abundantly. A type lesions on the leaves of muck paddy plants tended rather easily to form them. Accordingly a high percentage of the lesions produced conidia on potassium-deficient, muck paddy plants may depend mainly upon their frequent occurrence of B and D type lesions which are capable of forming abundant conidia. Potassium deficiency hastened also conidia formation of B type on muck paddy plants.

(iv) Discoloration of leaves during incubation. When detached leaves are incubated in a moist chamber, sooner or later, discoloration will occur. Discoloration of the leaves in the early growth stage or of the upper leaves took usually such a trend as green→light green→yellow, and a period holding green color used to prolong; while that of the lower leaves in later growth stage or of those of potassium deficient, muck paddy plants indicated brown or dark brown color, and the discoloration went on rapidly. Leaf tip discolored more rapidly than the basal part.

Discoloration of the detached leaves could be distinguished into the following four trends, *viz.*, green→yellow, green→brownish yellow, green→brown, and green→dark or dark greenish brown. Number of the leaves discolored through each trend and the pattern of occurrence of each lesion type on them are shown in Table 9. C type of lesion was omitted because of its rare occurrence.

As will be seen clearly, the lesions on the leaves indicating G→Y discoloration were almost A type, and B and D types occurred exclusively on the leaves indicating brown discoloration.

Further the sporulation of A type-lesion on the leaves bearing A, A and B, A, B and D, B and D types respectively is shown in Table 10.

Table 9.

Trend of discoloration	Number of leaves bearing					Total number of leaves
	A	A, B	A, B, D	B	B, D	
G → Y	35	1	0	0	0	36
G → bY	8	5	0	1	0	14
G → B	2	2	0	1	0	5
G → dB, dgB	0	17	3	6	2	28

Table 10.

Pattern of occurrence of lesion types	Trend of discoloration	No. of leaves	Sporulation of A type lesion		
			Number of lesion	No. of lesion produced conidia	%
A	G → Y	35	321	20	6
	G → bY	8	75	32	43
	G → B	0	—	—	—
	G → dB, dgB	0	—	—	—
		43	396	52	13
A, B	G → Y	1	5	0	0
	G → bY	5	43	30	70
	G → B	2	4	2	50
	G → dB, dgB	17	130	98	75
		25	182	130	71
A, B, D	G → Y	0	—	—	—
	G → bY	0	—	—	—
	G → B	0	—	—	—
	G → dB, dgB	3	8	8	100
		3	8	8	100

Sporulation of A type lesions on the leaves taking G→Y trend was very poor (6%), and that on those taking G→bY trend was rather good (43%). It was remarkable that A type lesions occurred together with B or B and D types on G→B or G→dB, dgB trending leaves showed the increased sporulation (50–75% or 100%). The leaves indicated dark brown discoloration and produced abundant conidia all over the surface after 4–5 days' incubation.

(v) Some observations on sporulation. A type lesion: After a few days' incubation in a moist chamber it developed a slender aerial mycelium at the central part (necrotic part) and sometimes formed a few conidia sparsely on the yellow zone (venenate zone) around the lesion. There were many lesions which developed no mycelium and they did not form conidia usually. In some cases conidia were formed on the yellow or greenish yellow part apart from a lesion itself after prolonged incubation. This may point possibly to a mycelial outgrowth from a lesion towards senescent tissue around it.

B type lesion: Aerial mycelia developed on the necrotic area near the periphery of lesion and then a few conidia were formed sporadically on this area. The

conidia production extended further to the discolored area around a lesion with an increasing abundance. In some cases it occurred on a considerably distant area from a lesion possibly by mycelial development through veins. Thus, in an extreme case, the leaf-surface was covered with densely formed conidophores and conidia, and turned to dark greenish brown.

C type lesion : Sporulation usually delayed as compared with that of B type. During incubation it turned mostly to B type.

D type lesion : Sporulation of this type occurred with much more abundance and rapidity than that of B type.

Conidiospores were formed usually on the conidiophores grown through stomatal aperture and not on aerial hypha spread over the leaf surface.

From the results of the present observations it can be said that the blight lesion may become to enlarge when the host tissue to be infected is in senescence. Senescence does not mean the so-called "nutrient deficiency" or a simple senile decay of the host tissue, as will be seen from anomalous dye-back of leaves in the field and dirty discoloration of dead leaves. Enlargement of a lesion may indicate a further development of the invading hypha within the infected host-tissue. So it can be assumed that a sufficient development of the pathogen in host-tissue may be a prerequisite to the enlargement of a lesion. Poor or nonsporulation and a long duration needed for sporulation by a minute lesion (A type) may imply the above assumption. Transition of lesion-type, as seen in Tables 1 and 2, and sporulation on a distant part from a lesion during incubation would also indicate that a poorly developed hypha at a standstill might begin to grow again under favorable conditions.

Recently Shimada¹⁵⁾ observed an abundant sporulation all over the surface of leaves which died by the occurrence of numerous blight lesions, and pointed out that, in the field, it will be one of the important infectious source of the present disease. In the present investigation it was observed that the sporulation covered a leaf surface occurred particularly on the dead lower leaves. In such case the fungal hypha might spread thoroughly within the infected leaf tissue. The relation between sporulation and hyphal development within host tissue above mentioned, however, should be proved by further histological investigations. Standstill or death of the invaded pathogen may fall eventually into the resistant reaction exerted by the host tissue against it.

V. Summary

The authors inoculated the blight fungus on rice plants which were grown in pots containing ordinary or muck paddy soil with or without potash fertilizer, and examined the rate of appearance of each type of the blight lesion produced on their leaves. Degree of conidial production on the respective type of lesion was also observed.

(1) Lesions developed after the primordial stage tended clearly to enlarge as compared with those that had been so far formed. Large type of lesion produced more frequently on lower leaves than on upper ones, especially with the potassium-deficient muck paddy plants.

(2) On the small type of lesion (A) only a few conidia were produced and the time required to their formation was much prolonged. On the leaves developed before the primordial stage and the upper (young) leaves even at a later stage, no conidia were produced on such small lesions. While the large and middle size of lesions (B, C and D) produced abundant conidia rapidly. Especially on senescent leaves bearing a number of these lesions, conidia formation occurred all over the leaf-surface after their death.

(3) The leaves of potassium-deficient or muck paddy plants died quickly and showed a dark-brownish discoloration during their incubation.

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On Intensive Utilization of Common Grasslands

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I. Problems in the Research of Grassland Agriculture

1. Economic viewpoint in the researches of agricultural management on grassland

When we began to study economically the grassland agriculture, the issues aimed at had been as follows:

Usually, in treating the grassland agriculture, economically and sociologically, importance has been attached to two points: the ownership system (both under feudalistic and modern ownership) and the utilization of grasslands or forests. And in consideration of the ownership and the utilization, be it from historical or constructive view, the changes of grassland itself, for example into forest or field or arable land, have been comparatively underestimated, while the change of the form of ownership and utilization have been always emphasized.

Thus, it can be said that the problems concerning the grassland agriculture had been approached from two sides, broadly divided, prior to the commencement of our researches.

The first side was studied in regard to the system of ownership and common utilization: The establishment, development, and dissolution of the communality, and its transition to modern ownership and modern utilization. In the pre-war period this subject was studied from the viewpoint of the history of laws, and in the post-war more deeply in the fields of history, in relation to feudal community. Also in the field of economics, this subject has been taken up chiefly in relation to Land Reform.

The second one has been studied from quite a different viewpoint of raising and managing domestic animals in the branch of management as required from the angle of agriculture, particularly, of zootechnics. It has been considered the customary extensive and exploitative utilization of grasslands, for solving the problem of securing better nutritive sources of domestic animals on one hand, and the problem of increasing the productive power in grassland on the other. The necessity of more efficient utilization of grasslands has become more obvious. Hence, for the first time, a reformation of grass-land itself was, required,

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together with the change of the way of utilizing it. This standpoint, however, being closely connected with zootechnics as a branch of natural science, and being concerned with natural-scientific observation of pasturage, resulted in primarily demanding the advancement of utilization and improvement of grassland. Accordingly, it was inevitable that this demand was considerably lacking in the analysis of agricultural economy and considerations of the development of farm management and its system.

In short, it may well be said that this standpoint took into consideration the problem of improving grass land simply from the side of natural science and technique, without discussing how it is necessary for the actual farmer's economy to improve it.

The above two points were quite important subjects for us to begin our research of the grassland agriculture.

As the natural consequence of it, our research could not but be focused on the issue how to integrate more historical technical considerations for analysis of the present situation. The complexity of the issue lies in the point that the present situation of utilizing or possessing grassland, or, broadly speaking, the present situation of agriculture in Japan, is not of such capitalistic agriculture as to be discussed entirely from the point of industrial management, but of family and peasant management depending upon selfsupporting economy in it. Hence the following two problems have been emphatically studied in their own respective sides: The problem of the demand for reformation of management and technique in utilizing grassland on one hand, for the increasing commodity-productive form, in farmers' economy urges it; on the other hand, the problem of possession and utilization of grassland (entering a communality is an example of it) which is necessitated by the character of farmers' management that is still fundamentally family management in spite of the variety in degree and type.

In order to integrate the two phases, therefore, it was considered that the farmer's economy should be placed at the core of the matter. The analysis of present situation of utilizing the grassland and the improvement of the utilization of it could be realized by elucidating various elements and contradictions contained in the farmer's economy. In so doing, we may see that the actual state of the utilization, from the viewpoint of productivity, corresponds with the stage of development of economy or management of farmers and peasants. However, individual peasant managements being not isolated, something like the greatest common measure of the utilization will be obtained in case common utilization of the grassland is actually made, although each peasant may be in different phases in the stage of development. In the custom of such utilization, the element to sublate it is also produced by the development of management in some farmers. In order to understand this more accurately, the elucidation of the utilization alone that corresponds with the stage of development in management would not be sufficient:

The viewpoint from the productive relations that compose and determine the utilization and possession is also required. The ruling power that keeps and changes the conventional utilization has been considered chiefly in the course of establishment, relaxation, and dissolution of various relations in communal organizations, and in this case social relations have been too much emphasised to look adequately into the changes of the form of grasslands, forests, and fields. Therefor, we must study the change of grassland which accompanies the change of productive relation; this is connected with external capital in particular.

In this standpoint, the problem of utilizing and owning grassland is solely neither confined in the change of farmers and the parties of farmers in possession and utilization, nor limited to the improvement of productivity in grassland. So long as the grass land agriculture is the subject of our study, not the investigation on forest and field in general, but the harvesting and grazing in the grassland must be considered as the main object; in this case, the grassland must be understood to be always liable to change into forest, arable land, or pasture, according to the demand by management. The areas thus falling out of the rank of grassland do not cease to be the object of the study of grassland agriculture. The problem of the improvement of production in grassland is given a part of the general problem of forests and fields.

Lastly, what we want to point out anew, which is concerned with the above subject, is that the change of the form of utilizing forest and field may not only occasioned by internal moments in farmers' economy, but also by the requirements of social economy that surrounds farmers' economy. The external factor may be the pristine capitals (of land owners, merchants, horsedealers) or the modern capitals, or the policy of the government. These are the previously mentioned big elements that restrict farmers' economy, and the reactional restriction which affects farmers' economy cannot be disregarded, for the nature of the farmers' economy is impossible to escape from being influenced by contact with the capitals, in spite of the merchandise economy for which the farmers are striving. In usual studies, this viewpoint seems to have been not so clearly adopted. Seeing that the capitalistic methods of production is not still established in agriculture in Japan which still remains in peasant-family management, this viewpoint becomes more important. These external capitals and the policy directly affect the nature of farmers' economy, the mode of possession, and utilization of grassland, and its change into forests and farms. As the ways of contact of the external capitals and the policy for farmers' economy vary according to the stages of development, the variety of productive relation caused by the contact is manifold. There are dairy capitals, forestry capitals, and their policies that have appeared conspicuously and particularly in the post-war days; and it is also necessary to inquire into the correlation between their influence and ruling power and the in-

ternal necessity of farmers' economy for them. Although this problem is naturally contained in the already mentioned subject of analysing those matters from the viewpoint of the productive relation, yet the importance of it should be more emphasized.

2. The issue of the improvement of productivity in grass land.

The reason why we had to take the above-mentioned matters into consideration was due to that our study was intended to know the most effective form and method of utilizing grassland that may offer a basis for agricultural management, one typical conventional trend of which has been the attempts to introduce dairy farming. As a direct subject, there is the matter of examining the policies for the promotion of dairy farming, which forms of the basic agricultural policies at present. As will be stated later, our study was made also by frequent commissions from the Ministry of Agriculture and Forestry, and the fact will back up the chief subject of the study which aims at improving grassland and the effect of capital investment. It was already admitted even by some of those in the Ministry of Agriculture and Forestry, that the measures for the promotion of dairy farming have been so easy-going as to disseminate the notion that were improving grassland and increasing production will make dairy farming develop. As the result, most of the regions appointed as intensive dairy farm regions were merely the grass rich parts or the places where the farmers could not manage by field farming alone; the designation is considered to be done without examining the constructions and possible trends of development of the farmers' economy in the regions. Hence, the productive policy, especially the investment and the financing, produced many pastures which were improved but supplied no milk-cows.

In the above cases, the abundance of grass does not mean the mass-productivity of the grassland; the abundance of grasslands in some localities is due to their own social inevitable reason claiming its continued existence even if it had been left unimproved as wild grassland to be harvested and grazed. On the other hand, the scantiness of grasslands in some regions is due to their cultivation to make arable lands, or to the management that keeps them as plane forests as seen, but not to any geographical reason. The regions wherein the grassland decreased shows that their utilization as arable land or forest was more profitable there. All these correspond with the stages of the development of agricultural management in the regions. The improvement of grassland that disregards the inevitable inward forces of the management is utterly unrelated to the promotion of dairy industry.

Considering these points, we must discuss at the beginning of the study, after the observation of the above issues, what regions necessitate the improvement of grasslands, how to improve it, and how to solve the bottle-necks of the improvement.

Although the improvement of grassland, especially the high intensification (= to pasturing), may not change the state of grassland, it will be a rapid reformation in quality and stage. It depends in every sense upon the development of commodity production in farmers' economy, and it means the shift from self-supporting extensive common usage to commodity economical intensive individual usage. But the main purpose of the actual improvement of grassland lies in raising the productive power of it, both in purpose and in final result. Also the need of farmers and the purpose of the Governmental policy aim at the same. And the pursuit for higher productive power is practised naturally without regarding the rules of the previous productive relations. For instance, the pursuit is done, abolishing the conventional utilization system before the self-supporting common usage is made utterly useless. This is an inevitable inconsistency that emerges between the productive relations and the productive powers. When the economical necessity of the improvement of grassland is weak and the policy is practised carelessly in easygoing manner as seen in present day's inconsistent bagets in unexpected confusions. In this case, the very pursuit for the improved productive power becomes unsettled, making the improvement formal, and resulting in producing no substantial progress of farmers' economy. If the pursuit should be better conducted, still the farmers who cannot keep with the policy and the management will be disturbed in their own management: something like a "small enclosure" confusion will be begotten here. Such problems as stated above are contained in the subject of improving grassland.

If such a pursuit for higher productivity is taken up while admitting creation of modern small-scale commodity production unit among the farmers and further decomposition of the farmer class in the present stage of capitalism as inevitable, it would be of some value indeed, but the Governmental policy is not necessarily in this line. The Japanese Governmental agrofiancial policy, at present, does not aim at development of especially subsidy to individual management units. The farmers who find it profitable and suited to their own line of management to improve their grasslands will go to it by their own initiative, demanding financial aid if needed, but the Government will include indiscriminately all the farmers and peasants in an area disregarding wide individual differences in the economic status and interests, in formulating an improvement project, thereby causing oppression on the economy of the individual farmers. In this study, I have no space to discuss the financial policy of the Government in general, but it must be pointed out that such communal projects present the key problem in the entire grassland improvement policy. This problem arises not only from the requirements of Governmental policy, but also when we face the question of how we should treat the traditional usages, that is, should we inherit intact, reform or abrogate the common use or ownership after the completion of the improvement project? The inherent exigency of modernized grassland economy would naturally demand abolition or

at least drastic reformation of such past usages, but it must be considered that such reformation in the present case does not come from the inner urge but from the requirements of externally imposed projects, and that a still graver problem would follow, for, in Japan, the abolition would not mean a mere abrogation of an antiquated regime necessitated by the modernization of grassland management, but a serious sociopolitical problem in its wake.

Such are the outlines of the issues needing first consideration, and the following study will follow these outlines in principle.

II The Factors for Developement and Change of the Utilization of Grassland

1. The stages of farmer's economy and their characteristics

The settlements as the object of our study are the following 15 settlements in the 12 villages: Midori-machi Settlement, Towada City, Aomori Prefecture; Karouzi Settlement, Owani-machi, Aomori Prefecture; Shinden Settlement, Matsuo-mura, Iwate Prefecture; Hinoto Settlement, Tamayama-mura, Iwate Prefecture; 5th and 7th Settlements, Shizukuishi-machi, Iwate Prefecture; Wakigami Settlement and Kawaguchi Settlement, Takanosu-macki, Akita Prefecture; Takekoji Settlement and Myojin Settlement, Mogami-machi, Yamagata Prefecture; Otaki Settlement, Oguni-machi, Yamagata Prefecture; Toriihara Settlement, Takahata-machi, Yamagata Prefecture; Tano Settlement, Onikobe-mura, Miyagi Prefecture; Haranomachi Settlement, Onoda-machi, Miyagi Prefecture; and Hirose Settlement, Takine-machi, Fukushima Prefecture. The reason why we did not choose a village or town as the unit in these cases is due to that the unit of the utilization of grasslands is generally in the scale of a settlement or hamlet and that in one village or town the difference of the structure of agricultural management, and accordingly the difference of utilization of grassland was great among the settlements.

But this does not mean that the study of grassland agriculture is connected only with settlements, as separated from villages and towns. For example, the problem of unifying the comon properties must be considered in a scale of a village or even larger areas; in this case, we intend to sutdy how the problem is related with the subjective conditions of the settlement concerned, and how it is actually met. Therefore, problems of policies in agriculture, in village and town, and in prefecture, should be woven into an analysis of a settlement and the productive frame of the settlement should be inserted in the entire regional economical construction as a whole.

Now, as for the index of the analysis of farmers' economy in settlements, we will consider it summarily focusing on the fundamental points, and leaving the details with the other proper reports in which minute observations were made.

(i) Means of production.

Leaving the analysis of the construction of farmers' classes behind, the average situations of the ownership and the utilization of productive means in each of settlements will be discussed here. Table (1) was made by the investigation and examination of the width of arable land, the number of electric motors and major live-stocks, together with the yield of rice per 10 are and with the main marketable products; the details are omitted. Considering the other indexes mentioned later, the settlements were arranged in the order of advancement in commodity production: The group I includes the most highly advanced settlements in commodity production. A, B, and C, in each group indicate respectively the advanced settlements, the insufficiently advanced settlements, and the utterly unadvanced settlements, in the improvement of grasslands.

Firstly, what should be noted here is the significance of rice-fields in arable area per family. Among the main products for selling, rice still has the highest importance. It implies that the important point of contact with monetary economy lies generally in rice-selling—rice-producing. This route from producing to selling rice is controlled nationally, and the authority who contacts with and participates in the route is uniformly the agricultural co-operative association in general, so that the effects of rice-production upon farmer's economy are uniform. Consequently, the quantity of selling rice seems to show the degree of development of commodity economy. The portion reserved for family consumption laid aside, the sold quantity of rice is varied according as the width of the area and the yield per are. Roughly speaking, the product of the area of rice-field and the yield per are makes an index of commodity production. In the settlements of highly advanced group, this product is characteristically high.

Secondly, among the marketable products except rice, there is apple produced in Owani-machi. There, the apple-orchards occupy the bulk of the whole arable area, and both the amount of invested capital and the total price of sale are rather large; if apple-orchards are managed in the same scale as rice-fields, commodity economy will be more promoted by the farmer than by the latter. However, the grade of commodity economy in this case can be discussed only less accuracy than that in rice production by the area alone, for ages and breeds of the trees and the growing conditions bring about a great deal of differences in apple production. The above presumption can not be made until the discussion is applied to somewhat a large scale unit such as a settlement not a small scale one such as a household.

In the next place, live-stocks must be observed as another powerful index; milk cows, first of all. The number of milk cows per family denotes likewise the degree of commodity economy as in the case of the area of rice-field. There are some regions, however, wherein the commodity economy is found by minute examination to be exceedingly in low stage, although a lot of milk-cows have been imported: for example, Hinoto Settlement of Tamayama-mura. This seems to

Table 1. Agricultural Management of the Settlements as the Objects.

Group	grade of Improve- ment	Name of Settlement	Number of Far- mers	Cultivated Land Area per Farm Household				Number of Livestock per Farm Household			Number Motor Yield of per Farm House- hold	Rice Yield per 10Are	Main Products for Marketing
				ricefield	field	orchard	total	milk cow	ox	horse			
I	A	Wakigami	66	are 90	are 52	are —	are 142	0.41	0.09	0.42	0.5	Koku 2.81	rice, milk
		Tatekoji	46	102	20	—	122	0.90	0.30	0.69	0.8	2.47	rice, milk
		Toriihara	44	46	38	12	96	1.14	0.36	0.02	0.3	3.09	milk, apple, rice
	B	Kawaguchi	29	101	51	—	152	0.62	0.64	0.23	0.4	2.81	rice, milk
		Karouji	200	36	18	57	111	0.04	0.28	0.25	0.02	2.33	apple
II	A	7th District	44	91	32	—	123	0.77	0.13	0.41	0.1	2.41	rice, milk
		Hirose	113	48	46	—	94	0.45	0.48	0.10	0.2	2.44	tobacco, milk
		Midori-machi	28	72	90	—	163	0.32	0.32	0.61	0.1	2.04	rice
	B	Shiden	92	80	108	—	188	0.10	0.28	0.36	?	1.61	rice, cocoon
		Harano-machi	94	105	15	—	120	0.19	0.71	0.46	0.3	2.69	charcoal, rice, cocoon
III	C	Otaki	24	96	19	—	115	—	1.08	—	0.1	1.87	rice, cattle
		5th Dstrict	54	89	63	—	152	0.59	0.31	0.83	0.4	2.01	rice, milk
		Hinoto	72	115	115	—	156	0.56	0.01	2.51	0.04	1.45	charcoal, horse, milk
	C	Myojin	18	81	81	—	168	0.06	0.80	1.33	0.6	2.15	horse, rice
		Tano	33	?	?	—	?	0.09	0.88	0.21	0.1	0.71	charcoal

be due to the direct replacement of the traditional horse production with the milk-cow production (still under the system of self-supporting management of the horse production days) on account of the depression of horse market after the war, finding no other producible things because of the smallness and narrowness of the area of rice-field, and of low self-supporting capacity of dry field crops. As a result of it, tenanted milk cows are so numerous in these regions that the milk cow production cannot be regarded as an index of developement of commodity production unconditionally. From the table above, it is known that there is a considerable correlation between the area of rice-field and the number of milk cows. This means that it is difficult to introduce milk-cow, or, if introduced, it cannot serve for dairy farming as commodity production, when the management is not yet rooted in the commodity production, or conversely speaking, when the self-supporting end is dominant. In this case, if the said commodity production is connected with apple production, then the milk-cow production has something to do with the apple production, and actually in Karouzi settlement introduction of the milk-cows was practised by the small-farming class who came to a deadlock in the apple production.

The traditional horse production is still active in such backward settlements as Hinoto, Tano and Myojin, and in the 5th district in Nishiyama and Tatekoji Settlement. This partly due to their being old breeding centers of horses, but as a whole owes to the undeniable and unchangeable backwardness in management. One exception is Tatekoji Settlement in which some farmers still persist in horse production in defiance of dairy farmers (the details will be stated later). Feeding meat cattles in Otaki Settlement must be mentioned here. With the capital turned over once or twice a year, this management is less self-supporting compared with horse production, although the income in cash is not very much. However, as the capital that controls this management is the pristine capital of live-stock merchants so the marketing route (buying and selling) is completely under its command producing a group of cattle tenants. Thus, it will not be a mistake to regard this as a commodity production that is situated between dairy farming and horse production.

(ii) Construction of classes and commodity production.

With intention to discuss further the commodity production in each settlements Table (2) is presented below, in which the number of farmer families with regards to the areas they manage and the number of families according as their occupations, special or combined, are shown : in addition, the farmers' classes that are prominent in introducing milk-cows are given. Judging from this, the settlements are largely divided into the settlements in which the middle farming class of farmers possessing 1-2 hectare of farm-land is dominant, and the settlement in which small-farming class is dominant, and the settlements in which the distribution of classes is rather unifrom as a whole making no particular concentration,

Table 2

Grade of Group Improve- ment	Name of Settlement	Number of Farm Household by Size of Cultivated Land under Management						Number of Farm House- hold Classified by Full- time and Part-time				Milk-cow Owning Classes	
		Total	are 0~50	are 50~100	are 100~150	are 150~200	are 200~300	are 300~500	Full- time	Part-time			
			I	II	III								
I	Wakigami	66	5	12	17	27	5	—	22	34	10	are 100~200	
	Tatekoji	46	5	8	17	13	3	—	18	23	5	are 150~200	
	Toriihara	44	13	16	7	4	4	—	?			are 150~300	
	Kawaguchi	29	3	3	8	10	3	2	17	8	4	are 150~200	
	Karouji	200	34	56	54	37	15	4	118	57	25	are 50~100	
D	7th District	44	3	12	13	11	5	—	21	11	12	are 150~200	
II	Hirose	113	16	27	56	11	3	—	76	26	11	are 100~150	
	Midorimachi	28	4	5	4	5	7	3	?			are 300~500	
	Shinden	92	1	15	19	20	29	8	54	33	5	are 200~500	
	Haranomachi	94	20	19	16	14	19	6	59	17	18	are 200~300	
	Otaki	24	4	8	5	5	2	—	7	15	2	are —	
C	5th District	54	1	9	19	12	12	1	37	9	8	are 200~300	
C	Hinoto	72	8	9	13	20	21	1	19	38	15	are 200~300	
	Myojin	18	2	2	5	6	2	1	?			are —	
	Tano	33	12	8	8	4	1	—	?			are 150~200	

Note) Part-time I is mainly engaging in farming, and II is engaging in other jobs than its farming.

In the group I in which commodity production is comparatively developed the middle-farming class is dominant with the exception of Karouzi Settlement producing apples, and in the Group II, various types are contained, for example, the small-farmer dominant type in Otaki Settlement, and the types separated into both poles in Haranomachi Settlement. As for the Group III, Hinoto Settlement is composed of relatively large-scale farmers in management, and Myojin Settlement is of middle farmer class and Tano Settlement is of small farmer class ; in short, in this group too, no definite classification can be done. Therefore, with these constructions of classes alone the characteristics of the settlements, especially the degrees of commodity production, cannot be determined. But hence a question can be drawn out : In what classes are the main products actually produced.

As for the rice production to begin with, those who plays the leading part are the upper class farmers, as a natural course of things, the rice-production being proportionate to the area of ricefield. The settlements that are capable of a great deal of sale of rice are those advanced in dairy farming or other modes of commodity production, as observed already. So, turning to the item of dairy farming in Tables (1) and (2), it will be seen that high percentages of introducing milk-cows are shown by the middle-farming class in the settlements concerned. In those settlements, the milk-cows are also introduced to the upper-farming class, but the density of introduced cows is higher in the middle-farming class. On the other hand, in the settlements where the number of milk-cow per family is low, namely where the improvement of grass lands is not advanced, the milk-cows are introduced into the families of upper-farming class only ; as exceptional case, they are introduced limitedly into the small-farming class in Karouzi Settlement. In these settlements where the introduction is managed by the upper class, that is, in Midori-machi, the Fifth District, Haranomachi, Hinoto, what is remarkable is the inactivity of commodity production. We may say that the higher the density of the middle-farming class the higher is the grade of the introduction of dairy farming in the settlement, the advance in taking in dairy farming offers an index of the general status of the settlement : moreover, the commodity production of such a settlement is found to prosper better. In this case, the development of dairy farming is generally based on the development of rice-production (the area of rice-field and the yield per are). Also, the fact that the introduction of dairy farming is undertaken only by the upper-farming class, namely the class that possesses broader area of rice-field, in the settlements in which dairy farming is inactive, shows the relation between rice and dairy farming. It does not necessarily mean, however, that where the rice-production is developed, there dairy farming is also active. It only means, as it were, that a certain degree of development of commodity production is the basic condition to enable the dairy management, and that the most prevalent form of commodity production is rice production. Why is the rice-production the basis, then ?

In Karouzi Settlement, Owani-machi, almost all the farming families are engaged in apple-production, and in this sense monetary economy can be said to be strongly prevailing, even as commodity production, in this settlement. But the milk-cows have been welcomed by the petty farmers who were brought to a deadlock by depression of apple price, not by the chief bearers of the apple-production activity. This implies that apple and milk-cow compete with each other in the present stage of technique and scale. In Hirose Settlement tobacco is widely cultivated, but the grade of introduction of milk-cows is not high. In short, the above two cases show that all the commodity productions do not present the managerial basis for the introduction of dairy farming. The dairy farming, in its present day farm, relying on family labor and keeping one milk-cow or two per household, is liable to be correlated with rice production. The rate of marketable portion of the rice produced is greatly variable according to the total yield, unlike apple and tobacco. Normally speaking, the rice production is self-supporting when the rice field is scanty, being a little more than self-supporting when moderate, and is more for market than for self-support in the upper-class farmers. The need of dairy farming is considered to be most earnestly required by those who belong to the class from the middle to the lowest of the upper class, that is, who produce some quantity of marketing rice but who cannot live by the proceeds alone. This tendency is partly due to the Governmental encouragement of dairy farming. Anyway, a typical form of Japanese dairy management is seen, herein it is based on the fact that the agriculture is small-scaled, and the development of small commodity production is intended. Compared with these characteristics of dairy farming, horse- or cattle-production is carried dominantly in strongly self-supporting settlements for the purpose of supplementing the needed cash-income, and in these settlements many of the upper class are generally blessed with good feeding conditions. Therefore, the area of rice-fields has no special relation with horse or cattle-production; utilization and possession of grassland, pasturage, and funds etc. are rather concerned with it. The utilization of grassland was inevitable to rice-production in its low technical stage. But according as the advanced means of rice-production by introduction of chemical fertilizer, agricultural chemicals, agricultural machinery, and cultivation system, causing the abatement of the necessity of utilizing grassland, the possibility of the route from introduction of dairy farming to grassland improvement is opened and accelerated. Here is, too, an element of the correlation between rice production and introduction of milk-cow.

By these discussions we have made above, the productive construction of the fifteen settlements will be nearly understood.

2. The Indexes as Determinants of Utilizing Grassland and the Change of the Utilization.

Since we have discussed the development of farmers' economy in the settlements, then the question of the utilization and possession of grassland (including forest and field) in those settlements must be faced in the next place. The analysis of it is shown minutely in the other reports concerned, but two indexes will be taken up here in order to make its characteristics clear. Indexes as they are, yet the two are vague and obscure; the one is how is a settlement, that is, how its productive structure has received or kept the unification of its common property (forest and grassland) promoted politically since *Meiji* Era. The other is the degree of advancement of individual utilization and possession of the forest and grassland in view of development. It is certain, of course, that the discussion of the two points alone is not sufficient to enter into detail, and we will try to clarify the problem of the utilization of grassland premising the analyses in the detailed reports.

(i) Forms of unification of common property in the village.

The cases are scarce in which the unification progressed substantially, for instance, by afforesting, although these results are partly due to our investigation that attached importance to the subject of the improvement of grassland. The areas in which it progressed substantially settlements only are parts of Wakigami, Kawaguchi, Haranomachi and Karouzi among which is Haranomachi alone the grazing land, grassland, charcoal forest and timber forest have come to be managed by the town administration after the war. By the way, the chief purpose of the unification of common property of settlements lies originally in afforestation, and naturally it excludes the traditional self-supporting common utilization (the so-called communal system). Accordingly, in the exclusion of farmers' utilization, unification could not progress unless that the farmers' economy is ready for the exclusion. Seeing that all the unification in those settlements was very much formal, and that the afforestation was performed only in some settlements, it will be understood how it was difficult to make away with the conventional customs entirely.

But the formality of unification and the scarcity of accomplished cases of afforestation should not be regarded directly as the evidence of maintenance of the conventional utilization. Originally, the afforestation by unification is a way to produce village property or town property, and accordingly it is, so to speak, the grasp of forests by the upper in relation to commodity economy. But, if the forest should be grasped positively by farmers themselves in relation to commodity economy, then the unification will be found difficult to carry through. Karouzi Settlement and Midori-machi Settlement were the examples that showed it during the war.

In Karouzi Settlement, the development of apple production had been completed and the apple orchards were being extended into the common fields and forests of the settlement when the unification was practised (in the 11th year of *Taisho*). On account of it, the farmers' desire was directed to the individuali-

zation of the common as orchards, so that the afforestation to the exclusion of their demand was almost impossible. In Midori-machi Settlement, the common forests were disposed of by sale under the condition of cultivation of the cultivable parts and the rest was unified formally. In the settlement, the area of rice field per family is still insufficient in spite of the cultivation for rice field thus made, a fact showing that the area of rice field was naturally more scanty before cultivation, therefore what can be called the management of rice production might have occupied least importance. Hence, it is duly presumed that the requisition for the cultivation of common forests into rice field was born from the exigency for security of life, rather than from demand for development of the management of rice production.

In the other settlements, except the above two, the conventional customs can be said to have not lost in general by the unifications. Moreover, it will be also noticed that a few settlements in which afforestation was at least partly realized before the war are the settlements in which the farmers' economy was already developed. That is, where the production was active, the authority of village or town was strongly determined for the unification and the farmers were concessive.

In the next place, in Tatekoji, Otaki, Hinoto, Myojin and Tano Settlement the unification has not been ever attempted formally. Tatekoji and Myojin belong to a same village, and in the former dairy farming is promoted compared with the latter which mainly produces horse. The dairy farming was introduced and developed after the war, so that its commodity, productivity was poor when the horse production was prosperous before and during the war. This is the reason why the unification could be advanced in Mogami-machi, though it contained Tatekoji Settlement. Generally, in a village or settlement where dairy farming was introduced substantial unification was difficult to be carried out in the pre-war period. And after the war, the process of unification, expressly afforestation, can be no longer enforced now that the scheme to turn the commons to pasture land has come into concretion. The difficulty of the unification is the more enhanced, for to turn it to pasture land is also the demand by the farmers themselves. Therefore, the unification realized substantially in Haranomachi Settlement after the war shows that the commodity production has been less developed there after the war.

Nextly, there are not a few settlements that rent the limited land (for pasturing and grass harvesting) from the State field, having no common grassland. The unification, in fact, is out of the question here. The organization of the settlements are exceedingly weak also in such places. The representative cases are seen in the Fifth and the Seventh Districts in Nishiyama village. In the latter, more in the lowland, the rice-field area is large, although the grassland is limited, and the production has advanced since the end of the war. But the settlement system can be scarcely seen in it. Accordingly, the cultivation into grazing lands is performed there in some individuals' grasslands by the volun-

teers renting the lands. The volunteers consist of 22 members in total, but they are not supported by any communal or settlement background.

With the above brief survey, the discussion of the characters of the settlements is finished.

(ii) The advancement of individual utilization.

Individual utilization of grassland is not usually managed in its natural condition. If the grassland has been utilized for grazing, it naturally cannot be individualized. And in the case grass-harvesting, if it has been the sources of feeding and fertilizing in the management of horse production, then there can no need of individual utilization and individual management (investment of labor and capital) on account of the self-supporting economic character of the management. Rather, as the fact shows, 'firing' was being carried out for the purpose of maintenance, weeding and insecticide, saving at the same time the labor. The 'firing' is a technical form of communal management, and if this managerial form, though extensive, should be replaced by individual management, the burden of the individual will become very onerous. And in order to be able to bear the burden, the individual utilization of grassland must be profitable enough to set off it. It was impossible at least in the management of horse production and pre-war rice production. Here is the ground that did not afford the dissolution of communal utilization. A reallocation of the individual share is effected by annual lot-drawing in this case, but as the allotted utilization is confined to the harvest period, the management still remains a communal one.

Then, the consideration of the individualization must include the problems of the transformations of the grasslands into individual lands, orchards, arable lands and village lands, without merely limiting the consideration to the form of grasslands. Table (3) is presented in relation to this point.

Concerning the original states of grasslands, to begin with, grazing lands were of course in common utilization and grassharvesting lands were nearly in common utilization by settlements or by associations in the days of Farm-Land Reform. Only in Hinoto and Myojin Settlements, the custom of changing allocation was practised in comparatively early periods. This is partly due to the large area of land; intensive utilization is not done at all, half-way mowing in such cases rather hampering intensification, and it has come rather close to individualization than allotment in some cases, e.g., in Myojin. There are other settlements where the individualization has been realized without the stage of allotment after the war. Tatekoji, Karouzi and Midorimachi are the cases. Among these, in Midori-machi Settlement even the full ownership is individualized. This implies that the necessity of utilizing the grasslands was decreased (owing, also, to the abundance of grass-supplying areas such as dike and ridges between rice-fields), and that the choice is allowed at the farmer's request for cultivation or for afforestation etc. A similar tendency is also seen in Karouzi Settlement, where

Table 3 Utilization of Common Grassland.

Group	Grade of Improvement	Name of Settlement	Grazing Field	Grass-harvesting Field	Improved Field	Utilized Form of Grass-harvesting Field
I	A	Wakigami	—ha	49ha	10 ^{ha}	Divided by groups in utilization, each group consisting 10 farmers.
		Tatekoji	10	117	17	In 1949, partly individualized. The rest is utilized in common.
		Toriihara	85	—	—	Under the management of the Ferner's Union, for grazing milk-cows.
	C	Kawaguchi	—	29	—	Since 1949, partly afforested. The rest is utilized in common.
		Karouzi	—	143	—	In 1950, all were individualized, some parts were changed to apple orchards.
II	D	7th District	600	—	9	—
	A	Hirose	20	93	6	Cominon utilization.
		Midorimachi	166	80	9	Individualized, in 1954. Some turned into fields and forests.
		Shinden	386	25	20	Common grazing fields and pasturre are managed by Farmers Union.
	B	Haranomachi	329	625	7	Town management. Common utilization.
III	C	Otaki	—	55	*15	Settlement's ownership. Common utilization.
		5th District	600	—	—	—
	C	Hincto	910	543	—	all under common utilization.
		Myojin	85	43	—	37 hectare has been individualized. Remainder under common utilization.
		Tano	63	127	—	Common utilization by the settlement.

(note) * The improved 15 hectares of Otaki are not pasture, but wild grass field.

the individualization of wildgrasslands is applied to the management of apple orchards. In the other settlements, the conventional common utilization is usually maintained.

Here, let us look into improved grasslands converted into grazing fields. The right of utilizing of these is individualized in the other settlements except Tatekoji and Haranomachi, and even the ownership is individualized in Midorimachi as in the case of wild grasslands. The difficulty of communal utilization of grazing fields lies, as will be also mentioned in **III**, in the necessity of substantial investment for the management and cultivation of them. For instance, speaking of fertilization, the quantity of grass needed by individual farmers is naturally varied and different, so that if they have to bear equal charge for the fertilization they are to sure to voice complaints. In short, it is inevitably inconsistent to put a part of the management, which is depending on individual commodity production, into shares. Moreover, the method of co-operation, which is not planned in general out of the needs of individual farmers, is liable to depend on mechanical equal division in accordance with their holdings. By these reasons, the grazing fields follow the trend of the individual utilization. In this point, this differs definitely from wild grassland.

What should be pointed out in the next place are the transformations of grassland into orchard and arable land, both of which have been practised since early periods; since 1903 in Karouzi Settlement. Individualization is a natural conclusion in apple production. In Karouzi Settlement 218 hectare has been individualized five times since the first individualization in *Meiji*, and the majority turned into apple orchards. An important subject accompanying the individualizations was the exclusion of the communal users from other villages and towns, and actually 13 cases of such exclusion have been effected so far. The transformation is obviously done from the utilization of grassland, so that the land can be no longer the object of grassland agriculture. But the transformations of the grasslands to orchards, or to the arable lands, or to forests or to grazing fields, have been practised by rejecting and abrogating the conventional system of self-supporting utilizations of the wild grasslands. Admitting the differences in degree of commodity production in those transformations, yet ultimately all the different courses do not fail to present a common figure of attempts of commodity economy in the utilization of the forests and fields. Compared with it, the existence and the utilization form of the wild grasslands are definitely different in its stage and degree. Therefore, it is needed to elucidate the factors of the types of farmers' economy which combines the transformation with the rejection of wild grassland.

The above brief survey, with the analysis of farmers' economy in **1**, will explain the issues of the development of commodity production and reformation of grassland, and especially of dairy farming and improvement of grassland.

By the way, what naturally become the problem at the reformation are the

restrictions by productive relations. Brief survey has been done about the problem in relation to the communal utilization of grazing field, and we will treat it little more in details. As we have just seen, discarding communal utilization of wild grasslands cannot usually be done without its coincidence with the demand of farmers' economy. If the reformation is performed simply for the sake of policy, it only ends in a formal reformation, as actually seen in that case of unifying common property in some settlements, producing numbers of contradictions on account of backward conditions of the farmers' economy. On the other hand, if the opportunity of the reformation of utilizing grasslands is produced out of farmers' management itself, putting aside in this case the initiatives by Governmental policy and external capitals, still there is not necessarily born the upward course of abolishing the conventions.

First of all, the demand for the reformation does not arise from all the sides in farmers' economy; for instance, in some farmer's economy it may be demanded from the side of dairy farming or apple production, but it cannot come out easily from the sides of rice production and other field-productions. But when the farmers' economy becomes independent of either animal power or horse-manure, in other words when it gross to find it profitable to manage commodity production in no longer need of self-support in those points, then the individualization or the reformation will be advanced rapidly. In reality, however, the situation has not yet come to that phase. Accordingly, the reformation of utilizing grassland has the cause in itself for a forced compromise, though not drastic. And how the compromise should be arrived at is the question. If the demand for the reformation is weaker in the management, the more the compromise is easily made. For example, on account of the apple production in Karouzi Settlement that started in *Meiji* Era (1903), the bulk of the wild lands was divided into individual apple orchards to the extent of 218 hectares in contrast with 143 hectares of the undivided grass-fields lands, but the communal utilization of the grass-supply fields had remained until the division of them was carried out in 1950. Also in Midorimachi Settlement the cultivation was promoted since *Taisho* Era and the transformation into grazing fields partly began in 1941, yet it was only in 1957 when the division of the grass-supply fields was brought into practice. For backward examples, in Wakigami and Hirose the self-supporting grass-supply fields are still kept conventional in spite of the advancement of changing them into grazing fields; and although some of them were divided for the purpose of additional arable lands, yet they are still communally utilized. In these cases we can see that the farmers' economy still contains the two principles concerning the utilization of grasslands, the commodity economy and the self-supporting economy. Therefore, the settlements where the division of grass-obtaining lands has been promoted may show that the commodity economy has ultimately dominated the self-supporting economy in the farmers' economy in those settlements (even partial

reformation is a proof of the permeation of commodity economy).

By the way, the appearance of this in consistent unification in an individual farmer's economy is seen also in a settlement that is originally the subjective utilizer as a unit. It can be understood as the problem of the difference of demands by developed farmers and undeveloped ones. And the problem becomes a great disturbance when it is pursued from the point of productivity. That is whether the conventionally maintained right of communal use should be admitted or refused at the reformation.

This problem requires more detailed discussion, so that we will consider it concretely in the analysis of the improvement of grassland in the next chapter.

III. Intensive Utilization of Communal Grasslands : Problems in Improvement.

1. Three types of utilization of grasslands.

The communal grasslands hereunder comprise the grasslands traditionally used for gathering grass for cattle or horse feed and for grazing cattles or horse in common down to present days, and intensivizing or improvement means converting such lands into pasturage fields. Strictly speaking, it may be questionable to call a reclaimed lot with specially cultivated pasture grass a grassland, but such lands may be identified in nature with what is commonly called highly intensive pastures. Creation of high intensive pastures is usually carried out as cooperative projects, and the created pastures are mostly shared for individual utilization. So, if the actual exploitation is entrusted to individual farmers, but the first creation of the pastures is undertaken by cooperative efforts for improvement, we must also take up this stage in our discussion.

Now, in the first place, we will see what are apt to come forth as problems in concrete in the course of grassland improvement, while keeping in view the antagonism between communal and individual utilization concomitant with the commodity economic development of grassland utilization. In the following study on what factor expedites and what factor impedes the intensive exploitation, the types of development of utilization of communal grasslands will be classified into (A): Type of progressing improvement, (B): Type of frustrated improvement and (C): Type of undeveloped improvement. Some of the 15 surveyed settlements will be excluded from all these types, for these types have been established only with common utilization of grasslands as criterion. So, we will set up Type (D) as control, representing the case of individual highly-intensive pasture farming in settlements with no commons to speak of.

Under such a classification,

- (A) comprises Wakigami, Tatekoji and Toriihara from Group I and Hirose, Midorimachi and Shinden from Group II.

(B) comprises Haranomachi and Otaki from Group II.

(C) comprises Karouzi and Kawaguchi from Group I, the 5th District from Group II and Hinoto, Myojin and Tano from Group III

(D) comprises the 7th District from Group I.

In this list, we must make amendments concerning Kawaguchi in (C). In this settlement, pasturization remains quite underdeveloped in the communal grasslands, but some private owned fields and farms have been pasturized, in this respect resembling (D). Accordingly, we may see a hybrid of C and D in this case, denoted (C') hereunder.

It is obvious that the types of (A) to (C') in this order do not coincide with the order of advanced utilization of grasslands. As exemplified by Karouzi falling under Type (C), advance in grassland utilization does not consist only in rash improvement, for development in the direction of commodity economy does not always result in improvement of grasslands. But these two gradings are not utterly uncorrelated, for (A) comprises only settlements of Group I or II in which commodity economy is more or less advanced, and (B) comprises only Group II settlements. The settlements of Group I where the grassland improvement projects have been carried out without hitch, supported by commodity (especially, dairy) production, do not come into (B). When some non-dairy production, e. g., apple growing, advances, grassland improvement attracts no attention at all, and such cases of well-developed commodity production fall under (C). The antipodal cases of grassland improvement never being taken up, owing to underdevelopment of commodity economy, in Group III, also come into Type (C). Such correlation exists between the Types and the Groups apparently unrelated but inherently thus related. Standing upon such a basis, we will proceed to study the factors expediting or hampering grassland improvement in settlements per Type, and examine the points of inconsistencies in them.

2. Analysis of types of grassland utilization.

(i) Type (A).

This type comprise the largest number of settlements. The common cause of advance in grassland improvement in these settlements is the advance of dairy farming without exception. In development, there is of course some difference between Group I and Group II settlements, but at least, dairy farming has been introduced with effect in any case. In these settlements, as surveyed in chapter II above, the dairy farming is supported by considerably developed rice farming. In such development of dairy farming, the relation to dairy-industrial capital in such areas is also a problem. At Wakigami and Toriihara of Group I, a dairy plant has been set up by the capital invested by the farmers' union; at Hirose of Group II, the farmers' union and Morinaga K. K., a foremost dairy industrial concern, are

in competition and the dairy farmers' union is in the position of profiting from this competition. Shinden Settlement is an exceptional case, for the dairy operations here are under the management of the township and with the prosperous Matsuo Mine as market, the dairy farming is rather stably and steadily developing. In Tatekoji and Midorimachi, Morinaga and Yukijirushi, both first-rate dairy industrial capitalists, are in complete control, in the former settlement Morinaga's influence having been a great impetus in the establishment of dairy farming in the pioneer days. Such a leadership of dairy industrial concerns has never been a factor to be neglected in the development of dairy farming and has played a rather important part in the initiation and progress of grassland projects. We must, however, point out that there are some problematic points hidden herein, too, particularly in the position which the promoting class of such projects takes in.

Such promoters of dairy farming belong to the leading party of the settlement. In Wakigami, they are centered around the upper farming class. In Tatekoji, the upper farming class plus the officers of the settlement organization were the promoters. In Toriihara Settlement, the former landlords have become enterprisers and taken up the leading posts of the dairy farmers' union and the Nippon Dairy Plant financed by the farmers' union, showing the characteristics of pristine capitalists in raising milk cows and selling them to the farmers. In Shinden, the township authority has a strong hand in the leadership of dairy farming. Such a leadership by the upper class of the settlements has been serviceable in solving the problem of reforming the traditional customs of communal usage, for these customs were adapted to self-supporting economy and were not to be pushed aside unless the farmer's economic system undergoes a substantial progress. In fact, dairy farming has been introduced in the interim, but such a mere introduction of dairy farming is not enough to make the traditional usages entirely dispensable, for the fundamental nature of the peasants' economy still tarried in the stage of household commodity production. This difficulty of discarding the traditional usages in force and reestablishing new ones could be realized only by the force of active propulsion from the leading class of the villages and settlements. Thus, the project of grassland improvement was set on foot, but the propensities of the promoting class later on began to give different colorings to the questions and problems of subsequent development.

A discussion on the points of question arising anew in the postimprovement days follows.

The first difficulty arises from the fact that the grassland improvement was not pushed on by the dairy farmer's organization, but by the settlement system, from upside downwards, usually in the order of subsidy and financing arrangement by the Agricultural Ministry, Prefectural Government → Village Office → settlement → farmers. Such a stage of affairs is common to the cases of Wakigami, Tatekoji, Hirose, Midorimachi and Shinden Settlements, dairy farmers' union taking lead

only in Toriihara. That the improvement project could not be inaugurated in compliance with the demands of the farmers themselves was necessitated by the condition that the improvement projects drawn up without taking the prospect of discarding the traditional communal usages into account had to face the first problem of persuading the common users to waive and revise their traditional rights. Such an arrogation of traditional use is a question not to be solved by mere economic demand from the dairy farmer's side. When, however, the project of grassland improvement is thus promoted rather from the side of political consideration, there are many phases calling for compromise, especially compromise with the residue of unremoval traditional usages. In other words, improvement should be based on complete elimination of traditional usages and pushed forward on the basis of purer requirements, of agricultural managements at least in some part of the commons, and the next point of question arises from the indefinite to effect thorough emancipation from tradition.

This next question is that concerning the rise of new antagonistic relation within the settlement, in the form of antagonism between the dairy farmers and the non-dairy farmers. This has become an issue owing to the fact that the improvement project was put into forth by cooperation of all farmers, not excluding the farmers with communal right but no interest in grassland improvement calling for investment of funds. If, however, such farmers with low demand for pasturage, mostly non-dairy farmers were left out of the project, the problem of how to dispose of the communal rights of such excluded farmers would arise anew. In fact, such considerations have been pushed aside and entire-settlement cooperative projects have been pushed through, leading to emergence of conflicting interests between dairy and non-dairy farmers. For example, in Tatekoji, dairy farmers are in conflict with horse raising farmers and silk growing farmers. Here, the utilization of improved pastures, as shown in Table 4, is allotted per group but it is inevitable that in such cases, conflicts arise in maintenance and management of the fields, within the body of utilizers. The farmers feeling little demand for pasturage are naturally averse to further call for investment of money and labor. Consequently, the pastures allotted to groups including a number of non-dairy farmers are inferior in quality and are much in arrear of other pastures. To solve this difficulty, in Tatekoji the encouragement of dairy farming is pushed with characteristic emphasis. It is of course not so simple as to see it that the purchase of milk cows does assure the establishment of dairy farming, and so, a new form of communal by-laws and disciplines are now being enacted. In Wakigami, the farmers demanding intensive pasturage and those demanding larger rice farms are in opposition, the question of either communal grassland improvement or enlarging paddy fields being in controversy. In fact, when the individual sharing of the common improved grasslands was enforced, we see that the lots allotted to the non-dairy farmers would be led to devastation. Such an apposition of

Table 4. Current Utilization of Improved Grass-Land

Group	Grade of Improvement	Name of Settlement	Year of Project	State of Utilization
I	A	Wakigami	1956	Alloted to 43 farmers in the settlement for separate utilization
		Tatekoji	1954	Joint utilization by groups of all the farmers in the settlement, but the non-dairy farmers have shared the area allotted to the group for separate utilization but have let them go to seed.
		Toriihara	1956	Utilized for grazing, under management of dairy farmers' union, but applicants are too many for the area, so that the utilization has to be limited.
	C	Kawaguchi	/	/
		Karouzi	/	/
	D	7th District	1954	Rented in common by 22 utilizers, who use the land separately.
II	A	Hirose	1954	In separate utilization by all the farmers in the settlement.
		Midori-machi	1954	Harvested grass sold by bids till 1957. Land parcelled off for private ownership in that year.
		Shinden	1954	Shared to dairy farmers in the settlement for separate utilization.
	B	Harano-machi	1959	Utilized by 11 groups of 88 farmers including outsiders in separate units.
		Otaki	1954	10 hectare shared individually for separate use and 5 hectare reserved for common use.
	C	5th District	/	/
III	C	Hinoto	/	/
		Myojin	/	/
		Tano	/	/

interests becomes intenser in proportion to the advancement of the improvement project.

Such conflicts represent nothing but the conflicts due to the differences in individual stands coming to the forth in carrying out cooperative projects. A seed of inconsistency is sown when the inherently individual system of commodity production is fenced in on the side of usages adapted to self-supporting economy and has to bear continuance of communal utilization. This presents the greatest difficulty inherent to Type A.

(ii) Type (B).

The frustration of the improvement projects is first of all caused by the absence of inherent demand from the farmers' economy, that is, the stage is not yet set for investing funds for improvement and for maintaining the improved pastures. For example, in Haranomachi, milk cows are still scanty, but the town authorities are rather too enthusiastic in pushing through the premature plan of cooperative improvement, while the prospective dairy farmers utilizing the pastures are only too few in number, so that the pastures are apt to be locked askance as useless trashes and even to become waste land. In Otaki, not one milk cow is to be found and the grasslands were not turned into pastures but were put under projects of soil improvement, afforestation with trees producing feeds and compost materials, clearance of obstructions and laying pasture roads, but from the viewpoint of cattle breeding management such improvement projects were sheer burdens, and when firing came to be prohibited for protecting the "improved land," the complaint of added burden of mowing labor began to be heard.

The principal cause of failure in these settlements lies in the outstripping of the farmers' necessities by the political or technical leadership. In this case, the contradiction comes out on the surface and takes the form of standstill or frustration of the project, the internal conflicts among the farmers remaining more hidden than busting out, but such conflicts are not entirely absent, for in Haranomachi too, the dairy farmers, though few, must feel the demand for grassland reformation, but they are kept from giving vent to their complaint as a minority group.

Thus, in the stage of Group II of farmers' economy, it does not make sense to project improvement of a grassland on the ground of only that because it is there, and will remain useless till measures are effectively taken to assist the improvement of the farmers' economy by leading in dairy farming. We fear that some settlements now classed in Type A may fall down to Type B, and the settlements of Group II are more likely to take the lead in the degradation.

(iii) Type (C).

This type comprises the three subtypes comprising 1) Karouzi Settlement 2) Hinoto, Myojin and Tano and 3) Kawaguchi ranked as (C') above.

The cause for the improvement project unformulated in Karouzi is the competitive prosperity of apple production; here, grassland improvement would have been taken up, if ever, by petty peasants who cannot manage dairy farming with profit, and so in this settlement there has been no opportunity of grassland improvement to be visualized. In contrast, in the three subtype 2) settlements, the commodity production by farmers is too undeveloped to wake up demands for grassland improvement, for in Hinoto, some farmers have taken up dairy farming, but the farmers' economy is still generally in the stage of self-supporting system and as the rice production is very low, no inner urge is felt

for grassland improvement, while in the other two settlements, no milk cow has ever been introduced and the economic stage remains at the level of self-supporting farming, so that no demand for grassland improvement can ever arise. On Kawaguchi Settlement Type (C'), it would be more convenient to speak in the next paragraph.

(iv) Type (D).

In the 7th District, as shown in Tab. 4, 22 dairy farmers have rented grass fields from 7 land owners and made reclamation work in common, shared them in different areas according to the requisements of the individual farmers, who pay the rents accordingly and maintain and use the pastures separately. Of these 22 tenants, 5 are residents of other settlements, so that they do not compose a settlement organization, but only a union of dairy-farmers by common interest, and there is no occasion for internal conflict. This mode of enclosure is not applicable to other settlements where traditional communal use is firmly established. If, however, the traditional rights can be canceled in some way or other, this form of communalization by common interest can be effected with success. It depends on whether the traditional use of common fields can be canceled or not.

In Kawaguchi Settlement ranked as Type (C') above, the common fields have been used up for afforestation and private lots of fields are used for individual pasturage. The leader in the afforesting project was village headman in the pre-war days and is a landlord of considerable influence in the village, and this man of will is promoting the afforestation project.

3. Summary : Future problems in grassland improvement.

In the above, the author have discussed the causes of success and failures, the present problems and difficulties concerning grassland improvement projects in the several types and groups of settlements. In the following, we will take up the points of questions that must be faced, before the projects can arrive at success, as conclusion.

(i) Farmers' economy and demand for grassland improvement.

Here we have to scrutinize the following points :

(a). How far the farmers' economy has developed. Speaking more concretely, we must consider whether the economic result, the income and the expenses, after investment for the improvement project, will balance. At least the project should be initiated to meet the demand of dairy farmers and further, the project should be carried by the cooperation of such farmers as demand it from their economic standpoint, or it will lose the economic foundation.

(b) When the improvement project is borne out by the settlement, the individual shares of investment are often defrayed from the settlement's common fund. Now, a reliance on such a subsidy (in substance) will make it even more hard to dissolve the communal solidarity of the settlement, the improvement pro-

ject will not succeed, that is, it would be frustrated, unless the economic basis is firm enough or the political support (financial investment by state) is reliable enough to make such settlement subsidy unnecessary.

(c) When the dairy farming is to develop economically, the price of produced milk, that is, the relation to the dairy industrial capital, becomes a factor of great importance for the farmers. In connection with the problem of how to rehabilitate the future dairy farming economy in Japan, or in concrete terms, how the lowering of cost of cow milk will influence the present system of dairy-farming economy, the existence of a dairy-industrial capital for petty dairy farming becomes a very influential factor.

(d) In the last place, the grassland improvement project should be always carried on, with the comparative study of profits obtained by dairy farming and other commodity production in view, and the mode of utilizing the grasslands should be selected in relation to the above capital for dairy industry.

(ii) Conciliation of conflicts in the production system.

This is connected with the fundamental characteristics inherent to petty farming.

(a) In substance, the cancellation of the right of traditional communal use would become an issue. But as this cannot be easily effected over all phases of field utilization, quantitatively the scope may be limited in this respect, and form the consideration of petty farming economy, such a limitation should be rather welcome.

(b) The reorganization into the new production types will act in the direction of disintegrating the existing settlement organization. To meet this exigency, specialization of the Farmers' Union system, in the form of special unions or special divisions in the union for different production types, has been initiated, but is not yet advanced enough to disintegrate the settlement organization. The above-cited partial cancellation of communal right, however, will act in fortifying these particular economic organizations, to the detriment of the settlement solidarity.

(c) Disintegration of settlement organization is as yet very little advanced, (as compared with that in the rice-only producing areas) in the dairy farming villages, even in the settlement where grassland improvement has been taken up. This may be due to the higher self-supporting faculty in the dairy farming areas, but in essence, to the stronger influence against settlement organization exerted by the rise of productivity in rice-producing areas. In such cases, a heightened profit-earning capacity by dairy farming will help the influence of rice production interests in disintegrating the settlement organization.

(iii) Policy concerned with grassland improvement.

What is the governmental policy aiming at as the picture of future dairy farming in Japan?

(a) There is a standardized policy that makes light of individual differences

in farmers' economic stands, and the uniformity by region, and a penchant for cooperation in disregard of individual management. Such a unity in formalism is apt to lack in attention to individual production types on one hand and the traditional usage on the other.

(b) Is not the policy apparently aiming at the average maintenance of farmers' economy involved in a common improvement project, taking the course of limiting the dairy farmers in Japan to the stage of petty dairy farming of 1-5 milk cows per family? How will the government give assistance to the trend of specialized dairy farming? In addition, it seems quite difficult to bring about a high-grade communalization in the present form of dairy farming in most areas.

(iv) Limitations of grassland improvement

The limits to the dairy-farming economy, and consequently, to the grassland improvement enterprise in Japan, are set by the fact that the dairy-farming type here is of petty household management. Such a pettiness is a burden not only of the dairy farming, but of agriculture in general of Japan, and quantitative enlargement of the petty dairy farming managements make this burden even heavier. When such an enlargement is realized, the production cost of milk will rise and the part of cost apportioned to the self-supporting will have to be augmented, and on one hand the disintegration of communal usages will be retarded while on the other hand the level of livelihood will be pressed down. But such problems already exceed the scope of a study on dairy farming or grassland improvement. All the questions discussed in chapters II and III above originate in this current limitations of petty peasantry, that is, single commodity production. In addition, such a single-commodity production economy has not yet got rid of all phases of self-supporting economy, hampering all attempts at specialization and large live-stock breeding. Breaking off such limitations is a problem posed not only on dairy farming, but on all fields of agriculture, in the present-day Japan now in the stage of monopolistic capitalism.

An attempt to abolishing such limitations, though in a small way, has been initiated with vigor, not as an attempt at developing the individual petty economic units as such, but as an attempt at cooperative enterprise. How this attempt should be nurtured in the field of dairy farming is a problem awaiting future solution.

ABSTRACT

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VOL 12, No. 1 (p. 1-146)

Studies on the Physiological Function of the Roots System in Rice Plant, Viewed from the Nitrogen Nutrition. Hideo OKAJIMA

I. Introduction

The idea of phasic development with regard to the growth of rice plants has been defined by a series of excellent nutriophysiological studies ever executed by our predecessors, and as a result, fertilizer application technique has also made great strides in progress of late. Meanwhile, studies on the roots of rice plants, urged by the problem of root rot diseases in the degraded paddy-fields, have contributed to the accumulation of the knowledge about the rhizosphere of the paddy field soils.

The former studies, that is, the nutriophysiological ones on the rice plant, however, have dealt with the shoot as their subjects, exhibiting a tendency to be carried on a stand-point independent of and different from that which the latter studies, — studies on the roots, have been carried out. For this reason, the analysis of the growth and function of the roots in response to the growth of the shoots is still in its primary, and unsatisfactory stage. Consequently, desire has come to be aroused for studies on the latter problem from the side of fertilizer practice with regard to the improvement in the technique of rice plant cultivation. Especially, studies on the roots have come to be regarded as important matters to take up as a problem of judging the activities of roots on the practical side of cultivation.

Not a few studies on the roots have dealt with a unicellular plant or root apex tissues for the purpose of simplifying the object of the studies. And studies at this level have been furthered so remarkably owing to the progress in the means of experiments that the minute behaviors of a cell near a growing point have been clarified.

The studies accomplished in such a

simplified series, however, are not sufficient in many cases to satisfy the practical requirements, such as the diagnosis of root activities. The reason in that many of such studies reveal only the capacities of the roots under a certain condition.

In other words, the salts absorption, oxidation power and other physiological functions of the roots depend not only on a plant's hereditary characters but also on its physiological changes in the plant itself as a whole in response to its environment, before their specificity is fixed. In addition, the functions of the root system have the character of the root groups with old and young ones combined. In this sense, the author has tried to grasp the physiological activities of roots synthetically, not considering their functions separately, but through their relation with the other organs and their functions as a root system. That is to say, the present study aims at the clarification of the functions of the roots as a root system by investigating the development of the roots and changes in their physiological functions in response to applying nitrogen in the present experiments.

II. History of the studies ever executed

The summary of the literature related with the present study is given.

III. Functions of rice plant roots and methods adopted for the experiments

In this chapter are described the methods of the experiments on the absorption of salts and water, oxidation power or reducing power to the medium, and respiration regarded as the principal physiological functions of the rice plant roots,

and is added the basis of the classification of the roots composing a root system.

IV. Relationship between the development of the root system and the top growth of the rice plants different in their nitrogen nutrition.

Three kinds of rice plants different in grain-straw ratio were grown in water culture in different methods of supplying nitrogen to investigate the dynamics of these rice plants and the functions of the root system. And the following results could be obtained: (1) the development of the root system, the salts and water absorption, and other physiological functions show a relation with the growth of the tops, and (2) their dynamic relation develops on the basis of the nitrogen nutrition of the rice plants.

For example, in the series where no nitrogen has been given since the ear-primordia stage, the nitrogen kept within them is preferentially distributed to the growing parts, and incomplete stems and minor tillers with because the nitrogen within is robbed of by their main stems and tillers. In this case, the root system takes part in competitive distribution through the basal part of the stems. That is to say, owing to the re-distribution of nitrogen, the nitrogen content in the basal part of the stem gradually decreases, but, so long as its concentration shows a little more or less than 1%, young roots develop, even after the nitrogen supply is stopped.

The characters of the root system observed in the early stage of nitrogen deficiency are an excessive increase in dry matter weight per root length, and the decline of its physiological functions. In other words, the respiration and oxidation power of each component root of the root system decline, and the values old and young roots show approach each other, and besides, both the roots begin to assume a little reductive character. As for salts absorption power, increase can be observed only in nitrogen, and the absorption of phosphorus and potassium is apt to decrease.

When the nitrogen content shows a little more or less than 0.5% after such a stage, the condition of root differentiation is

removed and the emergence of young roots comes to a standstill, each root exhibiting an extraordinary elongation of its own, with less lateral roots, by making use of the nitrogen having been kept within till then. For this reason, the kinds of the component roots are simplified, and in addition the dry matter weight per root length increased in the previous stage begins to decrease again, brining with it the decline of the sugar content. As a result, each root constituting the root system has had less relation to the shoots, and the absorption power of salts and water also decrease; still weaker becomes the oxidation power of the roots than that in the previous stage; the rhizosphere reductive, and hydrogen sulfide observed to appear in the medium.

When nitrogen deficiency progresses to a still greater degree, until the nitrogen content of the root is 0.7%, even their extraordinary elongation stops, and the progress reaches its terminal stage. During the period the salt absorption power declines extremely, the roots show an abnormal response to nitrogen, and potassium is ready to be excreted out of the roots. Moreover, no increase in the absorption of phosphorus owing to applying nitrogen comes to be recognized, their oxidation becoming powerless.

Concerning to the top growth of the series, however, regulation period of tillers is short and the development of each stem appears uniformly. Thus, the series demonstrates a clear distinction of each development stage in addition to the highest ratio of grains to straws. In the case of the rice plants, to which no nitrogen has been given until the ear-primordia stage and then, nitrogen has been supplied until the maturing stage, the interrelation between the nitrogen nutrition and the functions of the root system kept existing in the process almost diverse [to that mentioned above.

Namely, although the increase ratio of root number of plants in the series is small at the early stage of growth after the commencement of nitrogen supply, the number of roots increases steadily until the maturing stage and the kinds of the component roots become various, after

the basal part of the stem secures the condition to develop new roots, owing to keep nitrogen content above 1.5% level within.

Concerning the physiological function of the root system in this series, the reductive character at the period of nitrogen deficiency, disappears and the oxidative character is revealed with the development of young roots during the period of nitrogen supply, regardless of any growth stage. The oxidative character, of course, depends on the strong oxidation power of young roots, containing high nitrogen, and having developed under the sufficient nitrogen nutrition.

In this series, tillering takes place profusely from the stem elongation stage, and the physiological age of tillers constituting the plant is disordered to such an extent that the heading period lasts as long as one month. And this series shows the lowest ratio of grains to straws.

Thus the relation between the development of the root system and its functions is in many cases controlled by nitrogen nutrition, so that the change in the state of nitrogen nutrition in response to growth may be able to take part in forming the characters of the development and physiological functions of root system accompanied by the development of the rice plant.

V. Salts absorption of rice plant roots and their nitrogen metabolism

The functions of the root, not as separate ones but as a root system, are mentioned as having a character as a group of roots quite different in relation with the shoot, and then an analysis of such a relation is tried, based on the difference between the functions of intact roots and excised ones.

In general, when there exists some nitrogen in the experimental solution, the absorption of phosphorus is promoted. As was mentioned in the above chapter, however, the absorption of phosphorus declines in proportion as nitrogen deficiency comes to an excess, such a relation being able to be recognized also as the difference in absorption power between intact and excised ones. That is, the respiration of intact roots, in communication with the

shoot, increases owing to the nitrogen existing in the outer medium, and with it the absorption of phosphorus becomes vigorous. In the case of excised roots, however, applied nitrogen causes them to respire actively, but weakens their absorption of phosphorus on the contrary.

The reason can be inferred from the experiment on the inhibition of salts absorption by 24 DNP. It depends upon whether or not the coupling reaction between the increase in respiration accompanied with nitrogen assimilation by the roots, and the other physiological functions goes on smoothly. That is to say, the excised roots, which are cut off from the shoot, lack in the cyclic reaction, because they have nothing supplied by the shoot, nor is possible the translocation of what has been assimilated at the roots. Therefore, it can be conjectured that the respiration of the roots increases without any effect, and that the absorption of phosphorus is prevented. And this coupling reaction is easy to take place at young roots, while it does not go on smoothly at old ones, so that the former resemble intact roots in character, while the latter, excised ones. The decrease in the absorbing power of phosphorus caused by applying nitrogen, which is observed in the roots deficient in nitrogen, is thought to be reaction similar to what the latter shows, on the ground that the same roots have already had less relation with the shoot. From above it is concluded in this chapter that a root system can be regarded as a group of many kinds of roots, which are respectively different in relation with the shoot.

VI. Salts and water absorption of rice plant root system

It is mainly clarified that the function of the roots must not be regarded as a sum of the activities of each root, but is expressed in interrelation between old roots and young ones. Rice plants, whose old and young roots were separated on both sides, and which were in the internode elongation stage, were cultured artificially, and by using them, difference in salts and water absorption between both the root groups was examined under varied

conditions. The fact mentioned at the beginning is based on the phenomena observed after the examination, which are described below. The contribution rate of young roots to the absorption of salts and water is comparatively lower than that of old ones. However, in the case where either one or the other of them is removed and the rest is forced to take part in meeting the demand from the top, the young roots are more vigorous in the complementary functions than the old ones, that is, the former absorb not only much more water but also more salts with it. In other words, young roots, which really have a large capacity of water and salt absorption, are comparatively less responsible for the activity when they co-exist with the other ones as members of a root system. Old roots, on the contrary, contribute to the supply of water and nutrient, and, if urged by a condition, play a principal part in the absorption of salts. Furthermore, in the treatment mentioned above, they show less relation to their top, or they bear little relation to young roots in complementary reaction, exhibiting their absorption power independent of the environment.

The specific characters of the young and old roots show respectively in water and salts absorption can be regarded to reflect their difference in nutritional state in response to their growth between the two kinds of roots. Old roots are apt chiefly to take part in the absorption of water owing to their position and large absorption area. These roots which have advanced in growth, and possess comparatively less content of nitrogen and potassium, are low-salt high-sugar ones. Young roots, on the other hand, constituting mainly of those in the process of cell division and elongation, are in the state of high-salt low-sugar with more content of nitrogen in their bodies, and they have high activities in oxidation power. Consequently, when the demand of a plant for water concentrates on the old roots, and the quantity of water absorption by the young ones is small, then the absorption of inorganic nutrient by the young ones ought to decrease in quantity. For this reason, the young roots

can be assumed to present a phenomenon that they show the supply of less water and nutrient to a plant, in spite of their high water and salts absorption capacity.

Thus playing a role of supplying water and nutrient to its top, and of oxidating the rhizosphere based on the interrelation between the young and old roots, a root system advances its expansion of its own surface area without contradiction. And such an interrelation is due to the nutritional difference between the old and young roots, so that it is kept smooth in the case of the rice plant root system amply fed with nitrogen. On the contrary its gradually becomes disturbed in a root system, in which the nutritional difference between the two kinds is slight, just like that of nitrogen deficiency, whose individual roots develop into a simplified, elongative system.

VII. Interrelationships between efficiency of nitrogen absorbed by rice plants for the yield of grains and development of tiller root system.

The interrelation between tiller root systems is mainly mentioned, and discussion is carried out on the relation between the dynamics of a tiller root system and the yields of grains. Experiment plots were prepared for the calculation of the efficiency of nitrogen absorbed for the yield of grains, and the growth of the plants in each plot was observed with respect of the tillers. As a result, it has been clarified that the highest partial efficiency of nitrogen absorbed for the yields of grains varies with the tillers. And as one of the causes is mentioned the difference in response to the deficiency of nitrogen between the tillers owing to the after-effect of pretreatment to the tillers and the content of nitrogen at the time of stopping nitrogen supply. In other words, some root systems develop by receiving nitrogen temporarily from their main-stems, showing further growth, and others, on the contrary, are early in turning to the direction toward their simplification. The difference in such a response between the root systems also has much to do with the re-distribution of the nitrogen among the tiller root system, when nitrogen is not

given from outer medium. In any case, there appears, it is pointed out, the difference in the physiological functions of the tiller roots, as mentioned above, in response to the change of nitrogen nutrition, and accordingly, respective tillers are different in the yield of grains.

Therefore, it can be understood that, also in the case of the tiller root systems, they have a character which is not regarded simply as a sum total of respective tiller root systems.

VIII. Nitrogen nutrition of rice plants and reduction of medium

It has been recognized that, in examining the development of root systems and the change in their oxidation or reduction power, all of them show a reductive character owing to nitrogen deficiency without regard to growth stage. This is thought to furnish useful hints as to the solution of the problem of the change in the physiological functions accompanied with development—especially the problem of root rot disease at a particular growing stage. Namely, in general, reduction powers of roots become great around flowering stage and root rot diseases become severe under degraded paddy field condition. And it has also been observed that the nitrogen content of the plant gradually decreases with the development of growth. Therefore, in this chapter various facts concerned are again brought collectively, added

by supplementary experiments, and then discussion is carried out on the reduction of rhizosphere by rice plants deficient in nitrogen nutrition. And it is concluded that the reduction comes from the following two sides — one is the singularity that the development of root system shows in response to nitrogen deficiency as was mentioned in chapter IV, and the decrease in their oxidation power, the other being the change in the activities of microbes accompanied by the decline.

IX. General discussion and conclusion

All the above chapters are summarized in this chapter for the discussion of the characters of root systems. And in conclusion the following are pointed out:

(1) The physiological functions of a root system do not appear only as a sum total of ability of each component root.

(2) They are always expressed in a close relation with their shoots, and based on a complementary relation between the component roots.

(3) The dynamic relations among the root systems are established on the basis of the change of nutritional state within the bodies in response to the development and growth of the root system.

(4) Owing to (3), nitrogen nutrition is an important factor in controlling the characters of the root system.

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VOL. 12, No. 2 (p. 147–159).

Decomposition of Organic Acids and Formation of Gases in Water-logged Soil.

Ichiro Yamane and Kazuo SATO

(1) Methane is formed under anaerobic condition by the specific microorganisms which are called methane bacteria. Methane bacteria can not decompose glucose and amino acids directly which are metabolized by most of microorganisms, but these can utilize some kinds of alcohols, volatile fatty acids and gases as substrates.

(2) In order to make clear the formation of methane in water-logged soil, the formation of gases, $\text{NH}_4\text{-N}$ and change of pH were studied in the decomposition of several kinds of organic acids. Organic

acids used are known to be formed under anaerobic decomposition of organic substances, i.e. Formate, Acetate, Propionate, Butyrate, Lactate and Succinate.

(3) When organic acids are added to air dried soil and incubated anaerobically, methane is formed in the following order. Methane can not be formed from Formate.

Lactate > Acetate, Butyrate > Succinate
Propionate > Formate

(4) When organic acids are added to water-logged soil and continued to be incubated anaerobically, the following

phenomenon can be found.

Methane is formed in the following order.

(i) in case of large amount of organic acids (C-120 mg/10 g soil)

Acetate, Formate, Lactate > Butyrate > Propionate

(ii) in case of small amount (C-15 mg/10 g soil)

Acetate > Butyrate > Lactate, Formate > Propionate

H₂ is formed before formation of methane only in case of Lactate added to water-logged soil.

This report will be published later in English.

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Physiological Studies on the Growth and Development of Rice Plant. Part 2. Environmental control of tillering in Rice Plant. Tuyoishi HONDA and Yoshiharu ODA

In the present paper, the authors investigated, in relation to the developmental process of tillering, the effect of temperature and day-length on the differentiation and growth of leaves in tillers and their correlation with those in the main culm. And those experiments were carried out in the air-conditioned darkroom with artificial light at the Institute to control exactly environmental conditions. The results obtained are as follows:

(1) In the consecutive 10hr. short-day condition, the number of tillers gradually falls as the temperature condition in the sowing stage becomes higher. In the upper limit of the definite high temperature condition, the elongation of leaves in all tiller buds is depressed and they can not sprout from the leaf sheath, before the stage of spike formation in the main stem. But after this stage, the tiller buds in the upper position which have been depressed and secondary tiller buds start to elongate and to emerge.

(2) The condition of relative low temperature in the early stage of development plays an important role in the sprouting of tillers and this effect remains as after-effect of temperature regardless of the higher temperature conditions during the subsequent stage of development.

(3) In the consecutive 16hr. long-day condition, sprouting of all tillers before the stage of spike formation can not be depressed even in the higher temperature condition, which differs from the case in the 10hr. short-day condition. These

facts may suggest that so far as tillering is concerned the long-day condition apparently corresponds to the relative low temperature condition in the early stage of development.

(4) In the tillering system, the node position of the main culm in which the tiller can sprout transfers to upper regions corresponding to higher temperature conditions in the sowing stage.

(5) Even when all tillers can not sprout from the leaf sheath in the higher temperature and short-day condition, the differentiation of leaves and spike in the growing point of tiller bud in each node position of the main culm proceeds normally and successively regardless of their elongation, corresponding those in the main culm. In this case the differentiation of the Nth leaf in successive leaves in the main culm proceeds simultaneously with that of the first leaf (prophyll) in the tiller bud of the (N-3)th node position in the main culm and so on.

(6) In the certain conditions, the differentiation of leaves in tiller buds of low node position in the main culm stops in a certain stage of development, but the regularity that corresponding leaves between the main culm and its tiller buds simultaneously differentiate, as above mentioned, is maintained during the early stage till the differentiation stops.

(7) The effects of the day-length and temperature conditions on tillering system in rice plants were also discussed.

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Studies on the Helminthosporium Leaf Blight of Rice Plant. 4. Conidial formation on the blight lesions Teruko ÔMATSUZAWA, Katsumi SATO and Masayuki SAKAMOTO

The authors inoculated the blight fungus on rice plants which were grown in pots containing ordinary or muck paddy soil with or without potash fertilizer, and examined the rate of appearance of each type of the blight lesion produced on their leaves. Degree of conidial production on the respective type of lesion was also observed.

(1) Lesions developed after the primordial stage tended clearly to enlarge as compared with those had been so far formed. Large types of lesion were produced more frequently on lower leaves than on upper ones, especially with the potassium-deficient muck paddy plants.

(2) On the small type of lesion (A) only

a few conidia were produced and the time required to their formation was much prolonged. On the leaves developed before primordial stage and the upper (young) leaves even at a later stage, no conidia were produced on such small lesions. While the large and the medium types of lesions (B, C and D) produced abundant conidia rapidly. Especially on senescent leaves bearing a number of such lesions, conidia formation occurred all over the leaf-surface after their death.

(3) The leaves of potassium-deficient or muck paddy plants died quickly and showed a dark-brownish discoloration during their incubation.

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On the Stand-Point for Studying the Land-lordly Sptem in Japan. Rin ABIKO

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VOL. 12, No. 3 (p. 217-260)

Decomposition of Glucose and Gas Formation in Water-logged Soil. Ichiro YAMANE and Kazuo SATO

Glucose is often added to soils in the incubation experiment, in order to accelerate the development of the reductive condition.

Since glucose is most decomposable for almost all the soil microorganisms, glucose experiment seems to be useful for estimating the decomposition of organic substances in the soil.

(1) Within one day after addition of glucose, the evolution of H_2 is very remarkable and then after two or several days H_2 is absorbed into soil again. The amount of H_2 formed and the time of its disappearance depend on the soil condition (especially redox condition) and the

amount of glucose added.

(2) CH_4 is formed after the disappearance of H_2 .

(3) Accompanied with the evolution of H_2 Eh_7 becomes vigorously lowered and then increases with reabsorption of H_2 . So Eh_7 at this time is governed by H_2 .

(4) The addition of glucose depresses the formation of NH_4-N and the increase of pH. But in a special case, in which pre-treated soil is used, the opposite phenomena can be found.

These results will be published later in "Soil and Plant Food (Tokyo)" in English.

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VOL. 12, No. 3 (p. 231-237)

On the Relationship between Grazing Habits and Vegetation of Grassland. Part. 8. The plant succession of rangeland at Kawatabi, Miyagi Prefecture, during 1955-1960. Shigeru IZUMI, Kietsu SUGAWARA and Zyunzi KUROSAKI

As the behaviours of grazing animals vary seasonally, the area characterized

with particular topographical features may be under its stronger influence. The remarkable examples are the stands adjacent to so-called "Umatateba" and the stands on the slopes, under continuous grazing pressure. Namely, there are heavily- and slightly-grazed area, respectively. In these stands, there tends to form the plant communities dominated by

Zoisia japonica and *Miscanthus sinensis*, respectively. When these stands are grazed moderately for five years, certain undesirable species to grazing cattle are replaced by grasses or grasslike plants which form the stable stage, viz. *Zoisia* type grassland.

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On the Stand-Point for Studying the Land-lordly System in Japan

Rin ABIKO

1. There are several points of controversy in the studies on the landlordly system (*Jinushi* System) in Japan, presenting seemingly insurmountable barriers against final settlement. In particular, the studies on land-lords under *Tokugawa* Era from the stand-point of historical science show great differences from those on the land-lord that prevailed since the *Meiji* Era down to the Agricultural Land-Reformation in the postwar days, as viewed from the stand point of economic science. Both the camps of researchers are equally concerned with *Jinushi* System in Japan, and yet there is a wide dissimilarity in their conclusion, say, the factors leading to the establishment of the *Jinushi* system, the ear of its first consolidation, the part played by the *Jinushi* and its historical and economic significance etc. But still, both the camps agree in regarding the *Jinushi* in *Tokugawa* Era and there involved in the recent Agrarian Land-Reform as essentially the same in character, but this indiscriminate notion has led to grave confusions.

For liquidating this confusion, the present authors have attempted to define the character of *Jinushi* system in Japan theoretically, and to throw light on the different standings they occupy, basing ourselves on the results of our past empiric studies.

2. *Jinushi's* land-ownership in Japan as well as elsewhere, e.g., the gentry land-ownership in England and the propriété bourgeoisie in France, is an institution born under absolute monarchy and is a transient form of land-ownership. It prevailed in the era of the facts dissolution of feudalistic

land-ownership system and is destined gradually to pass over into capitalistic land-ownership. Such a system of real property rights begets a specific economic system, which is the land-lordly system (*Jinushi* system) itself. Accordingly, the significance of the landlordly system is determined by what role it plays in such a transitional stage of economic construction.

From such a view-point, the landlord landowning forming the basis of landlordly system is produced by the disintegration of peasantry in the process of downfall of the estates of feudal lords (feudal crisis). The form of this disintegration of peasantry determines the economic significance of landlord landowning.

As is well-known, the disintegration of peasantry creates the classes of capitalists and laborers, in typical cases, but when commodity economy is low in development, the disintegration tends to produce land-owners and tenants. The creation of either of these two types by the disintegration depends on the grade of development of commodity production among the peasants and the difference is due to the degree of completion of market rules effective enough for accumulation of capital. Consequently, such a disintegration of peasantry will have different consequences according to the stages of capital accumulation. In the stage of the primitive accumulation of capital, the disintegration will produce landowners and tenants rather than capitalists and laborers, at least in the earlier stadium, because of the low development of commodity production, and capitalistic rela-

tions come forth only in the later stadium. But in the stage of capitalistic accumulation, the capitalistic population rules for capitalistic accumulation causes emergence of capitalistic relations on one hand, while the relative surplus-population remain in rural villages in the form of latent surplus-population and the disintegration is latent.

Therefore, the landlordly system should be observed in two categories, corresponding to the disintegration of peasantry in these two different stages.

3. In Japan, three different types of *Jinushi* system have been postulated, in the historical order of the *Murakata Jinushi* (village officials landlords) system that came into existence in the first part of 18th century and persisted to the latter days of *Tokugawa* Era in the mid-19th, the so-called *Jinushi* (landlords) system that began to appear in the latter days of the 18th century, and the parasitic *Jinushi* (not at all modern landowners) system born by metamorphosis of the preceding in the early 20th century and forming a pillar in

the Japanese capitalistic construction.

Of these three forms, the first *Murakata Jinushi* system is a substructure of the feudal regime of *Tokugawa* Era, a form adapted to feudalism, and as such, may be excluded from the pale of our study as being not a *Jinushi* system we are speaking of. Thus, the two latter represent the forms of landlordly systems in Japan.

The *Jinushi* systems of these two different stages cannot be treated in the same manner, for though they are similar in outward form, they gave different principles lying behind the disintegration of peasantry that produced them. The *Jinushi* system in the former stage should be studied as a system of transition stage in connection with the history of foundation of capitalism in modern Japan, and the *Jinushi* system in the latter stage should be tackled as a problem in the structural specificity of Japanese capitalism.

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Manometric Micro-analysis of Gas Mixtures and Some Problems of Gas Formation in Rice Paddy Soil. Ichiro YAMANE

Metabolism in rice paddy soil is performed by soil microorganisms under the anaerobic condition of water-logging. Substrates for these microorganisms are the organic substances which are derived from plant residue, farmyard manure and soil organic matter.

For many years there is a tendency to classify the soil organic matter into two categories, for instance, "Naehrhumus und Dauerhumus" or "decomposable organic matter and true humic substance." But the analytical methods for fractionation are usually very drastic, and so there are lots of difficulties for considering these fractionation with the activities of soil microorganisms.

In order to clarify the character of the soil organic matter as substrate for microorganisms, the writer attempted to investigate the gas mixtures and ammonium nitrogen as the endproduct of soil microorganisms under anaerobic condition.

The reason why there is scarcely the

investigation of gas mixtures is due to the various difficulties of gas determination, especially, the difficulty of handling gases and the lack of an adequate method for micro-analysis of gas mixtures.

The writer established the manometric micro-analysis method by using Van Slyke apparatus.

Contents of this Japanese report have been and will be published in English in "Soil and Plant Food (Tokyo)" and "Sci. Rep. RITU. D". Summary of this report is as follows.

Part 1. Manometric micro-analysis of gas mixtures, using the Van Slyke apparatus.

I. Principles of gas analysis and the characteristics of gases.

II. Van Slyke manometric method.

This chapter deals with the apparatus, principle and advantages of this method. The following advantages can be pointed out.

(1) This method can be applied to vari-

ous analytical method.

(2) Analysis by this method is far more accurate than the volumetric analysis (10-100 folds).

(3) Submicro, micro and macro analyses can be performed by using the same apparatus and reagents.

(4) Since analysis is worked in the closed system, measurement of gases is independent on the atmospheric pressure. So the balometer is not required.

(5) Correction for temperature change is scarcely required, because chamber is coated by water jacket.

III. Analysis of gas mixtures by using Van Slyke apparatus.

Van Slyke published several reports on gas analysis, but the descriptions concerning the micro-analysis of a small amount of gas and the combustible method of methane and hydrogen are not sufficient. The writer presents the analytical method of micro-scale by which the parallel analysis of gas mixture can be done by using 5 to 10 ml of gas samples. Combustible chamber is modified by the writer, in order to be more convenient for analysis. (Fig. 8). (This chapter was published in English "Soil and Plant Food (Tokyo) 6: 1-6. 1958.")

IV. Micro-analysis of gas mixtures in the flooded soil.

In the case of gas analysis in flooded soil, collecting gas becomes a problem before analysis itself which is described in previous chapter. The procedure of gas analysis consists of three parts, namely, (1) sampling soil containing gases by injector or incubating soil in injector (2) degassing and catching gas from soil (3) analysis of gas. This chapter deals with these procedures in detail. (This chapter will be published soon in English "Soil and Plant Food (Tokyo)". (in preparation))

V. Rapid method of gas analysis in flooded soil.

Since the solubility of gases is too small except CO_2 , other gases in water can be neglected in the case of a violent formation of gases such as the addition of the easily decomposable organic matter. In such case, gas phase can be introduced directly into the Van Slyke apparatus and analysed, and then CO_2 in the solid

and liquid phase can be determined by the method in chapter IV. (namely, by degassing procedure).

This method requires only one fifth of labour and time less than the degassing method. In this chapter is described the procedure of this rapid method, in which special devices for introducing the gas phase are originated by the writer. (Fig. 14) (This chapter will be published soon in English in "Soil and Plant Food (Tokyo)". (in preparation)

VI. Application of Van Slyke method to the other soil analysis.

Van Slyke method is not used widely in Japan except blood-gas analysis, but this method can be applied and recommended to lots of analyses because of its several advantages. After investigations by the writer, herein are introduced the several methods which can be applied to soil analysis, for example, determinations of carbon, amino-nitrogen, carboxyl nitrogen, and gases in water.

Part 2. Problems of gas formation in the rice paddy soil.

I. Historical review is mentioned briefly.

II. Experimental methods except gas determination are described.

III. Determination of gases evolved from rice paddy field. (1)-Composition of gases-

Gases evolved from rice paddy field are sampled and their compositions are determined. In the case of violent bubbling of gases, CH_4 percent is largest, N_2 and CO_2 continue, and H_2 and O_2 are very small. When gas bubbling is not vigorous, N_2 percent is largest and CH_4 and CO_2 percents decrease. O_2 percent increases at the afternoon when the photosynthesis of algae works actively. (This chapter was published in English with next chapter.)

IV. Determination of gases evolved from rice paddy field (2)-Quantitative determination of gases formed in soil and the estimation of decomposable organic matter.

In order to approach the actual state of gas formation in paddy field, soil samples are taken from the fields every three weeks and brought to laboratory. The soils are incubated at 30°C and then after

suitable period, gases and $\text{NH}_4\text{-N}$ are determined.

The amounts of CO_2 , CH_4 and $\text{NH}_4\text{-N}$ formed in the field are far larger in the muck field than in the alluvial field. Formation of CH_4 reaches the maximum at the middle of August. The amount of CO_2 formation is larger when CH_4 formation becomes smaller. An estimate is made for the amount of soil organic matter which is used by soil microorganisms and converted into CH_4 , CO_2 and $\text{NH}_4\text{-N}$. (This chapter was published in English in "Soil and Plant Food (Tokyo). 4: 25-31. 1958")

V. Factors affecting the gas formation (1) — Effect of temperature —

Since temperature is one of the greatest factors influencing the metabolism in paddy soil, formations of gas and $\text{NH}_4\text{-N}$ are studied in the range from 15°C to 60°C , using muck and alluvial paddy soils. From 15°C to 40°C which appear in the acutal field, the formation of $\text{NH}_4\text{-N}$, CO_2 and CH_4 increase with increasing temperature. Above 40°C their tendencies become complicated.

$\text{NH}_4\text{-N}$ increases with increasing temperature up to 60°C and CO_2 reaches maximum at 40°C , above which CO_2 decreases a little. CH_4 formation reaches maximum at 40°C , but it decreases great deal at 50°C and stopps at 60°C . Below 20°C , it appears very little.

In general, influence of temperature appears more in muck paddy soil than in alluvial paddy soil, because muck soil has a great deal of easily decomposable organic matter and so the microbial activities in muck soil is influenced by temperature much more than in alluvial soil. (This chapter was published in English in "Sci. Rep. RITU. D. 12: 1-10. 1961).

VI. Factors affecting the gas formation (2) — Influence of the amount of easily decomposable organic matter.—

When paddy soils are incubated for several months under the moisture condition of the field capacity, oxidative decomposition proceeds effectively and the amount of the easily decomposable organic matter decreases. Pre-treated soils and original soils are compared in the forma-

tion of gases and $\text{NH}_4\text{-N}$ after incubation under flooded condition.

In pre-treated soil, increase of pH and fall of Eh are depressed and formation of $\text{NH}_4\text{-N}$ and CO_2 decreases but CH_4 does not form at all. $\text{NH}_4\text{-N}$, CO_2 and CH_4 are studied as the endproduct of microbial activities and the following conclusion can be obtained, i.e. the easily decomposable organic nitrogen compound can be estimated by the amount of $\text{NH}_4\text{-N}$ formed under flooded condition and the amount of organic compound decomposed easily under strong anaerobic condition can be estimated by the amount of CH_4 . Macroscopically speaking, the amount of CO_2 formed shows the amount of the decomposable organic matter, but lots of problems still remain in CO_2 formation. (Most of this chapter was published in English in "Sci. Rep. RITU. D. 9: 69-83. 1958.")

VII. Nitrate reduction and nitrogen formation.

The writer succeeded to catch quantitatively the amount of N_2 formed by denitrification which has been a large problem in rice culture in Japan. Denitrification from other source except $\text{NO}_3\text{-N}$ does not become a problem. (A part of this chapter was published in English in "Soil and Plant Food (Tokyo) 3: 100-103. 1957.")

VIII. Decomposition of sugars and formation of hydrogen.

The amount of H_2 formed is usually small in the flooded soil, for exmaple, less than one tenth of the amount of CH_4 formed. H_2 formed seems to be absorbed by the hydrogenase in microorganisms in the soil. A great deal of H_2 can be recognized at the early stage in the decomposition of glucose and other soluble sugars. Such H_2 formation can occur when green manure containing soluble sugars is placed in the paddy field.

Since H_2 formation can not be recognized form formate, H_2 may be formed by *Clostridium*. (This chapter will be published later in English in "Soil and plant Food (Tokyo)".)

IX. Decomposition of organic compounds and formation of methane

Methene bacteria can not utilize glucose

and amino acid which are utilized as good substrates by almost all the microorganisms, and the substrates of methane bacteria are limited to fatty acid, some alcohols and gases such as CO_2 , CO and H_2 . But the formation of CH_4 by methane bacteria requires the strong reductive condition as well as the substrates above mentioned.

When the organic substances are added to the air-dried soil and then incubated anaerobically, CH_4 formation is more vigorous in the case of lactate and starch rather than in the case of acetate and butyrate, because lactate and starch are decomposed more easily and is more effective to make the strongly reductive condition than the direct substrate for methane bacteria such as acetate or butyrate. Formate has inhibitory effect on microbial action.

On the other hand, when these substances are added to the previously incubated soil which is already reductive, the direct

substrate such as formate, acetate and butyrate can produce CH_4 , more vigorous than other substances.

Propionate can produce CH_4 slightly in spite of the direct substrate for methane bacteria. But cellulose and gelatin can produce methane vigorously next to starch.

In this paper the writer reports what kind of substances can produce gases and what kinds of conditions have influences upon gas formation in flooded soil, as well as the method of gas determination.

Since gases do not have any nutritional effect upon rice growth, soil fertility can not be discussed from the gas formation. But this report which discusses the problems of gas formation as the end-products of microbial activities in flooded soil presents a lot of informations valuable for understanding the microbial action in a flooded soil as a complicated system.

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